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The Welding Engineer

Edited by L. B. Mackenzie

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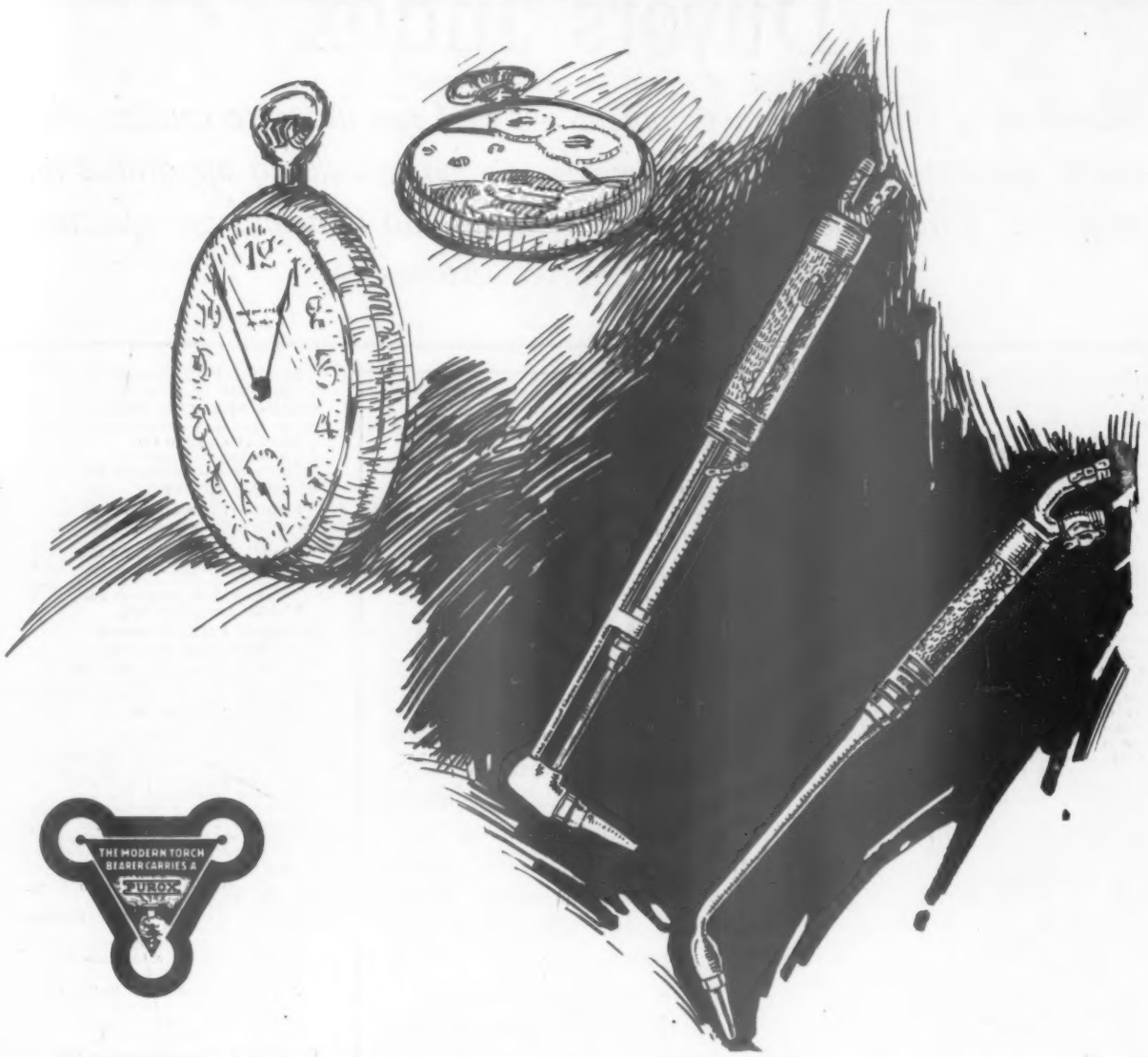

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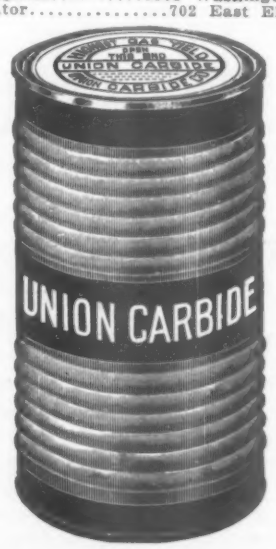

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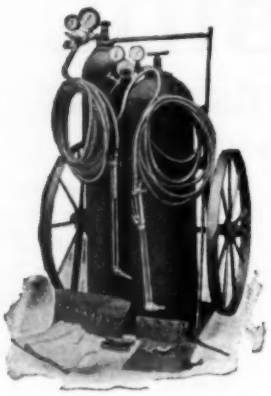

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GENERATORS
and SUPPLIES

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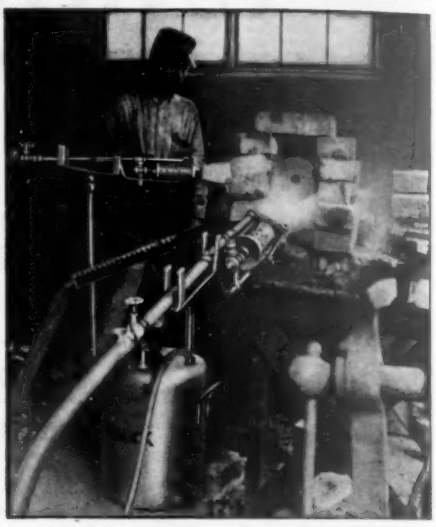

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There is absolutely no SMOKE or NOXIOUS GASES, and the DIRT that accumulates when charcoal is used is eliminated.

The burners are readily regulated to the desired flame by merely regulating the OIL VALVE.

HAUCK KEROSENE PREHEATERS are simple to OPERATE, and easy to HANDLE. They are equippel with hand pump; one pumping will operate the burner for three hours.

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Most efficient generator for producing Oxygen and Hydrogen

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CARBONS of Superior Quality for Electric Welding and Cutting. Carbon Specialties of all shapes and sizes for Gas Welding.

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No. 8-G for Natural Gas, $8.00

Preheating Blowpipes

The two most essential points in welding are:

FIRST: The use of a proper sized oxy-acetylene flame.

SECOND: The saving of gas by preheating your work for the oxy-acetylene flame.

The first is under your control in the use of the oxy-acetylene apparatus you have selected.

The second, we can aid you in by supplying the proper blowpipe for preheating purposes.

We manufacture blowpipes for use with Coal Gas, Natural Gas, Gasoline Gas and Acetylene Gas, with Air Blast.

Our catalog "B. X." free for the asking, contains full description and prices. WANT ONE?

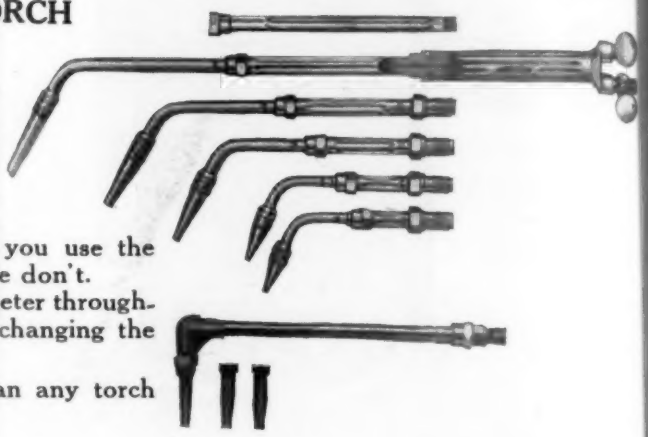
Buffalo Dental Manufacturing Co.
Buffalo, N. Y., U. S. A.

Is Your Shop

Do You Realize How Simple

AMERICA'S MOST SUCCESSFUL TORCH

Smith's No. 6

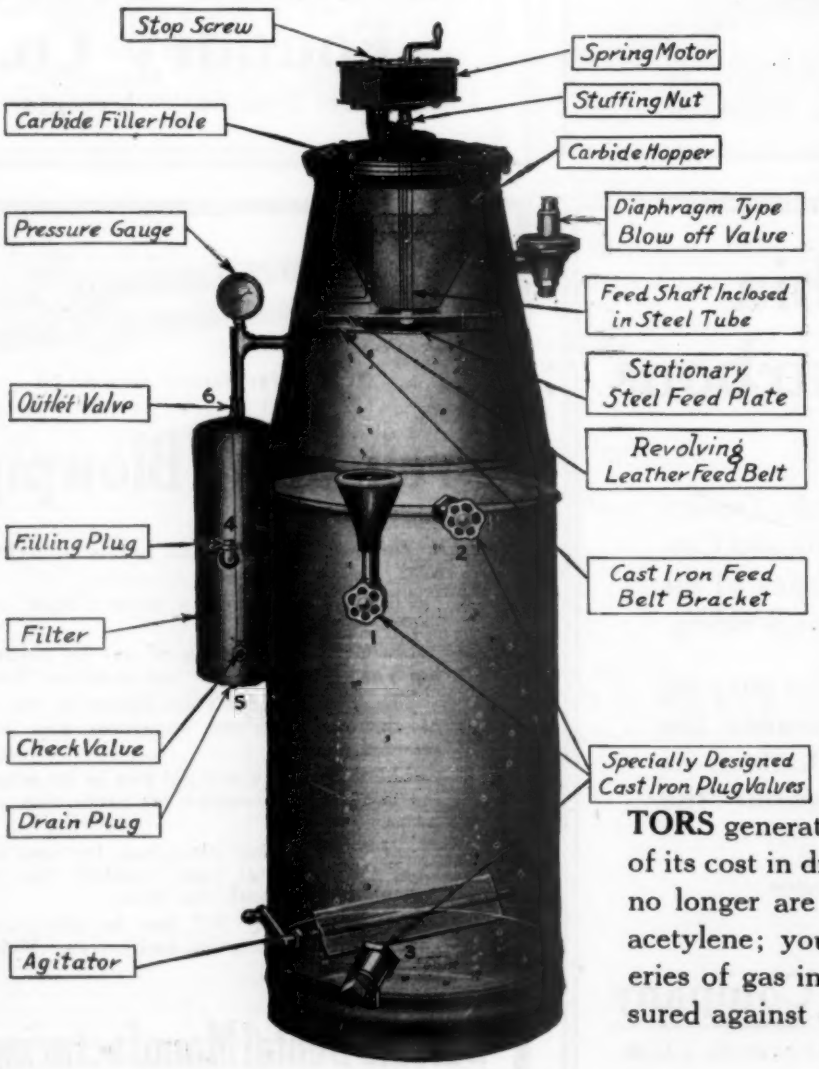


With Smith's No. 6 Torch you have as many different length torches as you have tip assemblies. All for the price of one torch.

Each tip assembly has its own individual mixing nozzle. You would not use the same carburetor on all gas engines. Neither should you use the same mixing nozzle on different sized tips. We don't.

The hole in the No. 6 torch tips is the same diameter throughout, and each tip can be dressed off without changing the flame.

This torch will stand more reflected heat than any torch we know of.



THE SMITH GENERATOR is of the simplest mechanism. This illustration shows the inside of a Smith Automatic Acetylene generator, and all of its working parts. You will see that there is nothing complicated, no rubbing parts to wear out, and nothing that needs to be closely watched.

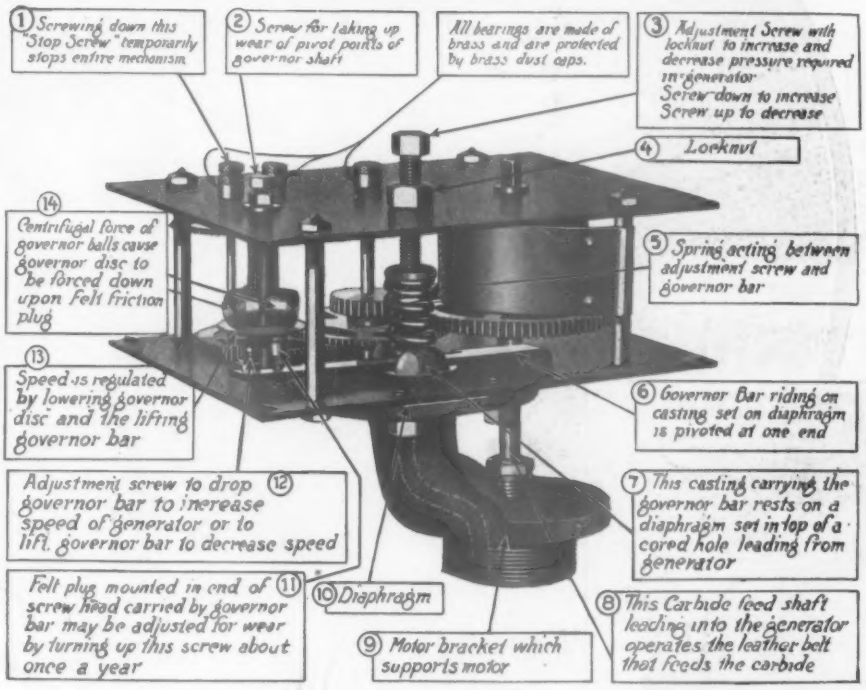
The illustration opposite shows the spring motor that runs this generator.

SMITH'S ACETYLENE GENERATORS generate acetylene in your shop at ⅓ of its cost in drums. With one installed you no longer are in danger of running out of acetylene; you are not dependent on deliveries of gas in drums; and your shop is insured against costly tie-ups.

ith Equipped?

able Smith Equipment Is Made?

THIS SPRING MOTOR which runs the Smith's Generator is shown here with the dust-proof case removed. Study its sturdy mechanism and superior workmanship. Notice that you can regulate it for the speed at which you want your generator to supply the acetylene, and that you can also regulate the amount of pressure you want.


1 Screwing down this "Stop Screw" temporarily stops entire mechanism
2 Screw for taking up wear of pivot points of governor shaft
All bearings are made of brass and are protected by brass dust caps.
3 Adjustment Screw with locknut to increase and decrease pressure required in generator Screw down to increase Screw up to decrease
4 Locknut
5 Spring acting between adjustment screw and governor bar
6 Governor Bar riding on casting set on diaphragm is pivoted at one end
7 This casting carrying the governor bar rests on a diaphragm set in top of a cored hole leading from generator
8 This Carbide feed shaft leading into the generator operates the leather belt that feeds the carbide
9 Motor bracket which supports motor
10 Diaphragm
11 Felt plug mounted in end of screw head carried by governor bar may be adjusted for wear by turning up this screw about once a year
12 Adjustment screw to drop governor bar to increase speed of generator or to lift governor bar to decrease speed
13 Speed is regulated by lowering governor disc and the lifting governor bar
14 Centrifugal force of governor balls cause governor disc to be forced down upon Felt friction plug

No Workman Wants to Fuss With Complicated Tools

That's why Smith's Welding and Cutting Apparatus is made simplicity itself. The simple, sturdy designs of all Smith's welding tools insure full value for your money,—high grade work neatly and quickly done,—little waste of time on bothersome adjustments,—and no waste of gas while the jobs are being done.

Smith's welding tools increase the speed of skillful operators and enable inexperienced operators to do good work.

THESE JOBBERS CARRY A COMPLETE STOCK OF SMITH EQUIPMENT

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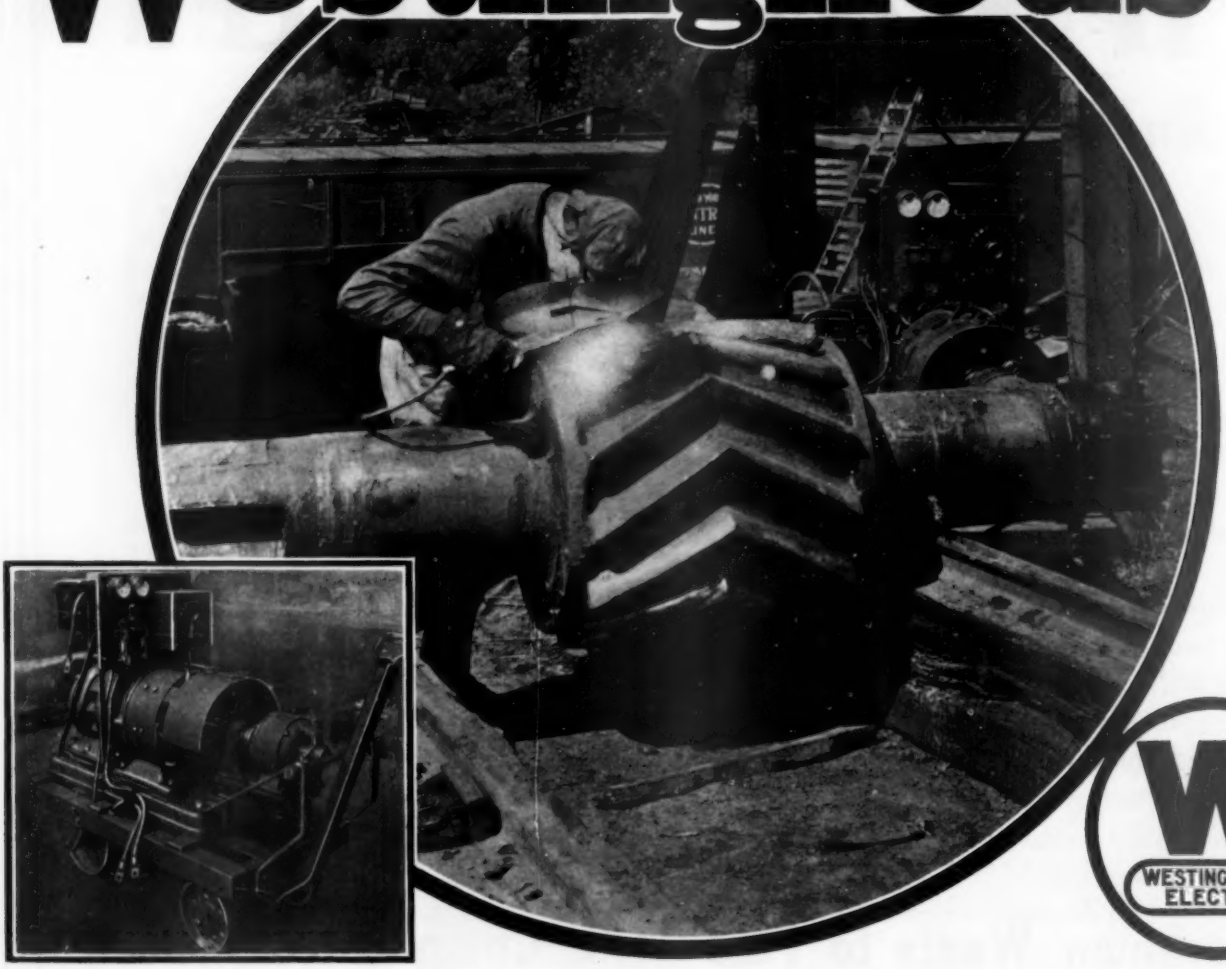
Westinghouse



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All costs on the job were under one hundred dollars, representing a saving of over $4,000 when compared with the price of new pinions, not to mention shut-down losses while waiting for delivery.

This is a single instance, out of many hundreds, where thousands of dollars are being saved on a welding job by having a portable Westinghouse welding equipment on hand suitable for repairs of all kinds.

Westinghouse Welding Equipments are designed for close current regulation, simplified control and rugged service requirements. The special Westinghouse scheme of field connections and the value of a separate exciter on a welding set are explained in Bulletin 7149. Write for a copy today.

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Hy—Gosh! How do you suppose people got along before Priestley discovered it?

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The former specification is responsible for near beer.

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"Raco" Electric Welding Wire is sold subject to rejection from *any cause*.

Furnished in coils or straightened and cut any length. Samples cheerfully submitted for testing.

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OXY-ACETYLENE
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"Raco" Soft Iron Rods for Oxy-Acetylene Welding

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the Strongest Bronze Made

for high-fire Brazing and Oxy-Acetylene Welding of Malleable Iron or Bronze and Brass castings assure a faultless, flawless job. This is another example of the "Cramp" standard of quality. This scientifically perfected metal is the result of long years of experience. Its fine physical properties make it especially suitable for welding purposes.

A strong weld of fine close grain and exceedingly tough texture is always the result where Cramp's Welding Rods are usesd.

We can also furnish Welding Rods of Cramp's Cast Iron, Cramp's Copper Covered Iron, Cramp's Vanadium Steel, Cramp's Drawn Aluminum, Cramp's Cast Aluminum, Cramp's American Iron and Soft Brass Brazing Wire.

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We furnish and will be glad to estimate on all kinds of brass and bronze castings.

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hose who have enjoyed long association with CANADIAN CARBIDE have always assumed high standards of performance We are confident that if not already among the users of CANADIAN CARBIDE the day will come when you too will know the meaning of "More Gas per Pound"

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As a surface plate and angle plate alone, this table is well worth the price to any machine shop or manufacturing plant. The width of the top is 30 inches and the length 30¾ inches. Net weight, 360 pounds; shipping weight, 475 pounds.

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Price, $35 boxed for shipment, F. O. B., Jersey City.

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Jersey City, N. J.

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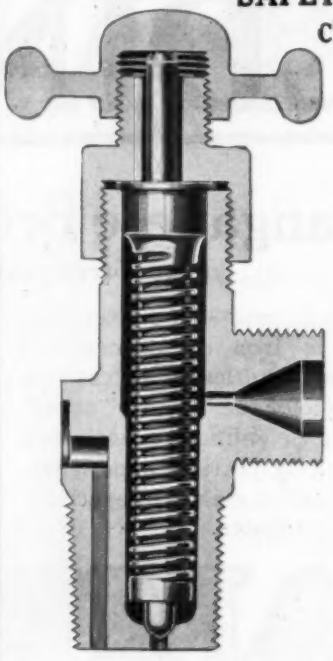
SAFETY HIGH PRESSURE CYLINDER VALVE



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Absolutely Tight Without Packing

LARGE REDUCTION IN MAINTENANCE COSTS, as it prevents leakage of cylinder contents in service or transit and prevents return of filled cylinders because valves cannot be opened.

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Minimum parts. Maximum sturdiness.

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Asbestos Welding Paper

THE original welding paper, that has stood the "Test of Time." Not the ordinary asbestos paper manufactured for many uses, but a scientifically prepared, long-fibre, pure asbestos paper developed for one purpose—to furnish a welding paper capable of withstanding hard usage and high temperatures without giving off noxious and injurious smoke, gases and fumes. Your men naturally can do better work when WELDOX Asbestos Welding Paper is used on every welding job.

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Asbestos Mittens, 23-inch length over all.
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—why not?

Make it a Federal

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"FEDERAL" Regulators are made of the very best materials by expert mechanics for expert welders who know the value of and appreciate absolutely dependable Regulators.

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Swift Oxygen must pass the most rigid tests —must never vary from its high quality standard.

Swift Oxygen is produced in the largest electrolytic plant in the U. S. A.—in ample quantities to render unequalled service to our customers.

The use of Swift Oxygen in your plant will aid you in raising the standard of the work of your operators.

The Name is Your Guarantee

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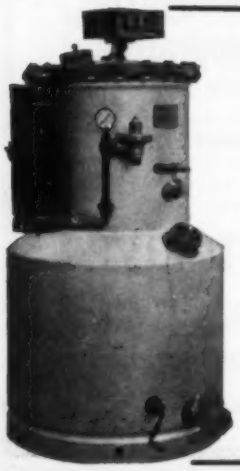

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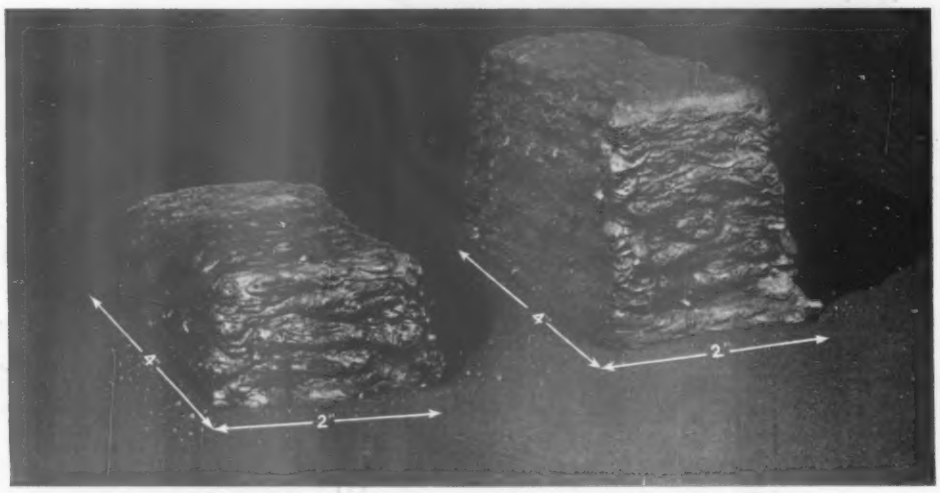

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EXPANSION AND CONTRACTION

A Discussion of the Fundamental Principles Which Make Some Jobs Easy and Others Very Difficult

By. B. Heyman

HOW often have we laughed at the quaint definition of summer and winter as expounded by a little school boy, "in the summer the days are long because it is warm, in the winter the days are short because it is cold?" And that same definition applies to metals in the summer and winter and through all varying temperature conditions. The hotter the metal, the larger its size becomes; while cooling from a high temperature produces the reverse action—decrease in size.

One of the fundamental laws, covering the action of metals, is that governing the variation in size as the temperature, to which the metal is subjected, changes. This article being concerned merely with the study of cast-iron, it is that metal whose action will be considered. Many are familiar in a general way with this action and probably know as a matter of fact that the change in size produced by cooling molten cast-iron to the temperature, at which it can be handled, is about ⅛ inch per foot. Especially those persons engaged in the founding of cast-iron or the related industry, (pattern making), where the shrink rule is such an important tool), appreciate what occurs when cast-iron is heated or cooled. And these people allow for the shrinkage; they study the requirement of every casting as it is handled during the molding, pouring, and annealing processes. And yet, there are numerous failures. Shrink cracks appear, or the casting is left with such strains that a fracture results at the first attempt to machine the casting.

Differences in chemical composition have a very appreciable effect on the "expansion," the term used to designate increase in size, or the "contraction," the term used to designate decrease in size. But, as it is not customary to analyze every specimen of cast-iron which it is necessary to weld; and furthermore, since foundry products are invariably of constant composition, we may assume that the changes in size, which rise or fall in temperature produce, are constant in all specimens of the same shape and size.

In welding broken castings, the filler rod is of such composition, that, allowing for volatilization, the final product is of practically the same composition as the metal adjoining the fracture. In other words, the added material may be assumed to be of the same nature as the rest of the casting, and, for that reason, should have the same characteristics. The skilled welder or engineer who specifies rod for cast-iron welding is well aware of the conditions which must be met under the hot action of the flame and demands a rod whose volatile elements are high enough in percentage to allow for the dissipation which occurs.

Let us now consider the simplest problem of metal action under heat influence and see what actually happens. A bar of rectangular section is so placed over two supports that there is no restraint on it as regards motion in any direction. If the bar is heated it will change in size, and the increase can be measured. If the bar is then allowed to cool, it will, upon returning to the original temperature, have its original size. This is dependent upon the bar being unrestrained and free to move according to the play of the expansion and contraction forces.

Assume that the bar in Figure 1 be 1 sq. in. in area and 12 inches in length at an initial temperature of 60° F. and that the temperature be raised to 2000° F. This is a case similar to the ordinary foundry problem excepting that the temperature change is in the opposite direction and from a somewhat different degree of heat. Had the bar been measured before and after heat application it would have been noted that the change was about ⅛ inch as stated in a previous paragraph.

This change can be calculated as follows:

l_1 = original length at temperature T_1

T_1 = original temperature

E = increase in length due to heating

A = coefficient of expression of cast-iron per 1° F. and per unit length, given as (.00000556)—Kent.

$$E = a\ l_1\ (T_2 - T_1)$$

$$= .00000556 \times 12 \times (200 - 60) = .1294 \text{ inches or } \tfrac{1}{8} \text{ inch approx.}$$

No permanent change has been effected in the bar during the entire sequence of heat application and removal; neither has any deformation or rupture occurred in the bar. But the reader will please note the emphasis placed upon the bar being unrestrained in its movement.

If, however, we take up one of the simplest of welding problems (using the same bar under almost similar conditions) an appreciable effect is noted. Consider a bar broken in the center and supported as in the previous example—without being restrained. See Figure 2. If welded at A, the material added at A will be at a temperature far above 2000° F. as assumed in the previous example and this high intensity will gradually decrease until the entire bar is evenly heated when the contraction in the bar will be uniform throughout the entire length. But what happens during the welding operation? Most of the applied heat is confined at A while the temperature of the rest of the bar is raised somewhat by conduction from A. If the bar were originally 12 inches in length, immediately after welding it would be slightly longer depending upon how rapidly the weld were performed and the quantity of heat introduced. Generally such a weld is performed so rapidly that very little heat is transmitted to the adjacent portions of metal. Upon cooling the contraction is confined mainly to the welded metal which draws in the end portions until the temperature throughout the bar has reached a stage of equilibrium, when the contraction is constant throughout the length. When cold the bar is generally less than 12 inches in length. Several factors influence the final length. Chief among these is the human element. A skillful welder working rapidly and applying the heat so as to distribute the forces properly can reduce the change in length to an inappreciable quantity. The length of weld is also an important quantity to be considered. Since the actions of expanding and contracting have been in no way restricted, the weld should in no way be affected physically. This is true if the sections are supported so that they are always in alignment. If sagging is permitted and the weld completed while the parts are out of line it can hardly be expected that the original bar can be produced.

Thus far it has been assumed that the bars were unrestrained. The next case to be considered is the same as the last problem, excepting that the ends of the bar are rigidly held. Figure 3 indicates a bar broken in the center and held rigidly at the ends so that there can be no motion lengthwise. Welding the break presents a new problem.

While heat is applied a pressure is created throughout the length of the bar. Being restrained from any end movement, the tendency is for the bar to buckle. Upon cooling, the contraction occurring at A, a strain results which will always produce fracture. This is, provided the welded area is of the same cross-sectional area as the rest of the bar. If the welded section is reinforced enough to make its welded efficiency greater than that

of any other section, the strain will still occur, but fracture will result at some other point of the bar.

The forces set up in metals by the addition or substraction of heat are irresistible. Cast-iron has a tensile strength of 18,000 to 20,000 lbs. per square inch. In the case of a bar held rigidly at the ends and allowed to cool from a high temperature, the force set up may be determined as follows:

S = unit stress in lbs. per sq. inch.

E = modulus of elasticity = about 14,000,000 for cast-iron.

A = coefficient of elasticity = .00000556

T_2 = say 2,000° F. — before cooling begins

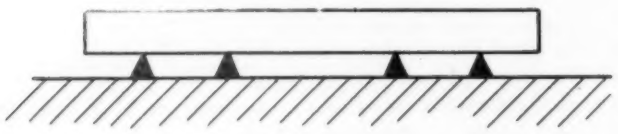


Fig. 1. Solid Bar Unrestrained and Heated.

T_1 = 60° F. — final temperature after cooling

$S = E\ a\ (T_2 - T_1)$

$= 14{,}000{,}000 \times .00000556 \times (2{,}000 - 60) = 155{,}000$ lbs. per square inch approx.

Such a condition is of frequent occurrence in most welding operations and forms the reason for many poorly executed welds, and also explains many failures which seem inexplicable to the welder who has not been trained in these fundamentals. The low tensile strength of the metal can hardly be expected to cope with so great a stress as the contraction strain sets up.

One of the simplest problems treated in welding text-books and instruction manuals is shown in figure 4. Welding the break at A without proper precautions, namely preheating, causes the casting to tend towards the conditions shown by the dotted lines. Here again, we have a welded member restrained by being tied at the ends. It is safe to predict a fracture upon cooling.

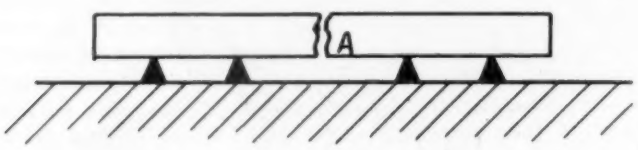


Fig. 2. Unrestrained Broken Bar Heated.

To eliminate such a possibility is very simple. Going back to the previous example we must remember that the arm A tends to shorten. The outside arms D and C however cannot shorten. Some means must be supplied to produce the same forces in all three arms so that contracting forces in all three will be equal, allowing all to shorten the same amount and at the same time. If arms D and C are heated to a dull red at the same time these two arms will lengthen. At the same time the two sections of A will be carried out, leaving a slightly larger opening than the original break. If the break be welded under these conditions and the entire casting allowed to cool slowly and evenly the contraction in all three arms will be simultaneous and the forces will be neutralized and entirely eliminated.

A practical example, although a trifle more complicated is shown in figure 5. Castings of this type are common to job welding shops. Generally such a casting is aligned and a brick furnace built around it, using charcoal to preheat the entire piece. The fire is started very slowly, allowing the heat to soak into all parts of the casting evenly. The intensity of the fire is gradually increased until the casting has become dull red. This permits the various members to expand at an equal rate, eliminating any abnormal strains that might develop were one member expanded quicker than any other one. The welds are then made and the casting allowed to cool very slowly. In cases of this kind it is very good practice to again bring up the heat in the casting so that the cooling will also be at an even rate. Strains are entirely eliminated by this procedure.

Another method of handling such a casting, without using a furnace, would be by "localized preheating." This method introduces an element of risk, but skilled operators rarely have any difficulties in accomplishing their aims by using the process. Weld A is made with the casting cold. To make weld B it is necessary to expand weld A so that upon contraction of B, A will contract at the same rate. To do this another torch is played on weld A and the section adjoining, keeping A at a dull red. After weld B has been made both A and B must be carefully protected from drafts and allowed to cool very slowly and at an even rate.

To make weld C is a little more difficult, since C is one of a series of members, all of which should be expanded before weld C is begun. Luckily this type of casting need not necessarily have to be accurate in its overall and sectional dimensions. Therefore enough expansion can be produced at certain definite points to spring open G, allowing the weld to be made. Upon cooling, a slight strain may be induced, but it is so distributed that little or no effect is produced. The sections to be preheated are at D and E, while the torch used for welding is at times played over F. Keeping D and E at a dull red, and also heating F, opens C enough to allow the addition of filler rod. The casting

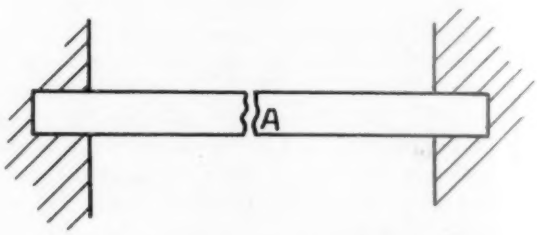


Fig. 3. Restrained Broken Bar Heated.

must then be carefully covered and allowed to cool slowly. Some strain may be left, since the action of preheating has opened C by means of a twisting action which is pivoted on all the members of F and almost in a line with point F.

The welding of large wheels, pulleys, and gears with broken spokes and rims are also intricate and difficult problems to the novice who tackles them, and even the trained and experienced welder often strikes a snag when a particularly fine piece of welding utters a musical sound like a crack after it has begun to cool and the welder is preparing to begin some other job. For the operator who is afraid to analyze his problem or, due to lack of experience is unable to do so, it is best to play safe. For such a one it is advisable to preheat the entire casting, although that is the more expensive method.

Generally some of the welds can be performed with the casting cold, that is, when some other break allows for the required expansion and contraction. But, preheating localized sections will allow for the final strain and so distribute it that it will either be neutralized or become a negligible quantity.

The filling of sandholes in large heavy castings is very often undertaken cold by many operators. The large mass of metal dissipates the heat almost instantaneously. No visible effect may be noted upon completion of the work. Still, the added material will shrink away from the original casting and produce checks and defects which may prove serious at some later time when the casting has been machined or is tested under pressure. Furthermore, the rapid cooling of the filler produces chilled cast-iron. In machining the welded portion, tools are readily broken and files so easily worn down without affecting the surface other than polishing it, that the casting is finally discarded as defective, and the welder blamed—as he should be.

Preheating is the only remedy, combined with that type of slow cooling which may be termed "annealing." The contraction of the casting simultaneously with the filler eliminates checking.

while keeping the temperature high enough prevents chilling, and the formation of the hard cementite—labeled "hard spots" by the machinist.

This is under the assumption that the weld is of such character that the entire casting must be heated. Uusually this is not the case, and proper additions of heat at points to offset strains which are apt to occur and to offset dissipation of heat by conduction will produce a perfectly satisfactory piece of work. "Compensating heating" as this has been labeled by a writer in the *Welding Engineer* is well worth considering in welding work.

"Compensating heating" obviously does away with preheating the entire casting. Localized preheating, the use of a large enough tip to bring the metal to the fusion point, (not use of a small tip which must be played on a small area for so long a time that deleterious results are produced) are sufficient

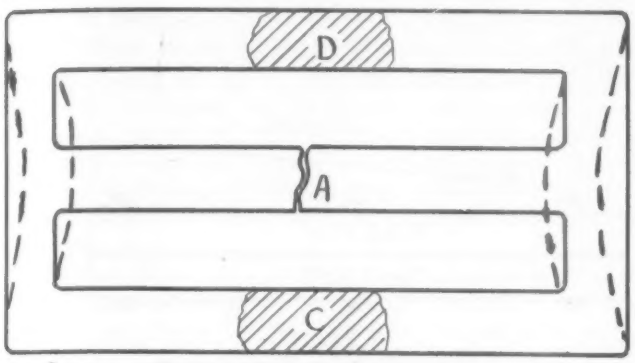


Fig. 4. Warping Which Preheating Will Avoid.

in most cases, with the addition of enough heat from the tip at the areas adjacent the weld to overcome rapid loss of heat from the added material after the weld has been made.

Machined cylinders such as are used in steam engines or automobiles must be handled very carefully. Uneven preheating causes warping which is even more serious than cracking the casting. Furthermore, the high temperatures to which these parts are subjected may produce sealing of the walls. This latter can be safeguarded by applying to the machined surfaces a heavy coat of grease and graphite. This preparation may be purchased ready mixed. To prevent uneven expansion the preheating agency must be controlled to such an extent as to add or substract heat very evenly from all parts of the casting.

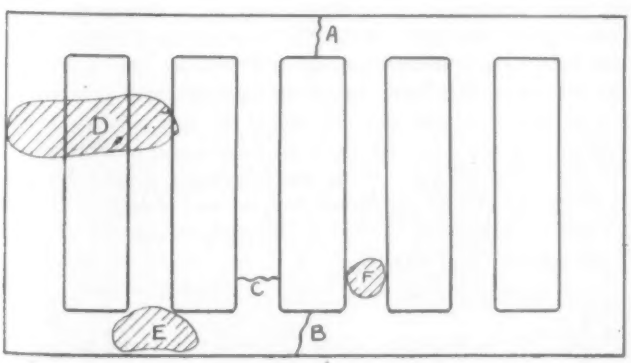


Fig. 5. A Practical Example of Preheating.

Forcing the fire must be avoided. A slow soaking heat that is evenly distributed is the ideal method. The writer does not express any preference regarding the fuel medium. Both charcoal, oil, or gas may be used economically and with perfectly satisfactory results. No matter which is used, it is essential that at beginning preheating, no more heat be added than will take the "chill" out of the casting and that further additions of heat be very gradual. It is also very important that the casting be so blocked that its own weight will not cause it to sag when it has reached a welding temperature. Dull red is the ideal point to begin work.

Summarizing briefly, it must be always remembered that expansion and contraction are irresistible. Unless the material is very ductile and has a high tensile strength, which cast iron does not have, there is only one means by which to forestall improperly executed welds. This consists in neutralizing or eliminating whatever strains are apt to be produced. Careful study is required and an analysis of the forces which will enter into and effect the casting during all the operations constituting the welding process.

WELDING "DURALUMIN"

By D. Richardson

Pure aluminum, owing to its relatively low strength and stiffness, has limited application in structural work. Strong and light alloys of aluminum have been investigated and introduced in recent years. These materials rival the strength of steel, while they are only one-third of the weight of steel. A group or range of these alloys are known under the trade name of "Duralumin."

A typical analysis of "Duralumin" is as follows:

	Per Cent
Aluminum	93 to 96
Copper	3½ to 5
Manganese	0.5 to 0.8
Magnesium	0.5

This alloy is manufactured in the form of wire, plate, forgings, stampings, etc., and possesses a strength ranging from 56,000 to 78,000 pounds per square inch and an elongation varying from 3 to 25 per cent. The melting point is in the neighborhood of 650 degrees C. (1,200 degree F.).

In the construction of aircraft of all kinds and their component parts "Duralumin" is specially valuable.

The oxy-acetylene welding of "Duralumin" is apparently easy if a welding wire of the same alloy and a good aluminum flux are used, and the welds appear to be perfect. But if the welded portion is submitted to a bending test, failure takes place after a very slight deformation. The metal possesses no ductility in the welded zone and cracks develop rapidly if the joint is bent slightly. In other words, the weld has a high tensile strength, but its resistance to shock is extremely small.

Welding processes, therefore, should not be used when the parts are liable to bending action or shock. Pure aluminum welding wire can be used as a welding wire when welding "Duralumin" and as the two metals melt at practically the same temperature, no difficulty is experienced. Miscroscopic examination shows that the joining of the added metal and the "Duralumin" is perfect.

It is obvious that the use of a pure aluminum wire gives a very flexible added metal in the welded zone, but the strength of the weld is very low because the strength of pure aluminum is only about one-fourth that of "Duralumin." The metal in the neighborhood of the parts melted by the blowpipe has the characteristic tragile structure of aluminum and the failure of such a weld from shock inevitably takes place where the added metal joins the base metal.

By acquiring an adjoining frontage of 56 feet, the Superior Welding Company, of Peoria, Ill., now has facilities for the construction of a building in the spring which will double their present capacity.

The Austin Co., of 16112 Euclid Avenue, Cleveland, has been awarded a contract for a one-story plant and basement that will cost about $50,000, to be constructed for the Rail Welding & Bonding Co., Cleveland.

WELDING MOTOR HEADS

Job Welder Avoids Warping by Bolting Two Heads Together Before Preheating

Kansas City,
Monday.

Dear Ed:—

The lad was quite right about that coast trip, I'm on my way now. Sorry that I couldn't run down and see you before starting but as things stood it was all I could do to get my belongings together and make my train connections.

Had to stop off here at Kansas City for a day and was rather glad of the opportunity to see the town, as I have always heard much about it, but have never had occasion to give it the "once over."

I picked up one pretty good kink here which is generally the case in shops of this nature if your eyes are open. It's been my observation that in the majority of shops where they are welding heads for gasolene cylinder blocks that there is always more or less warping of the finished surface and that in some instances it is found necessary to refinish this surface in a planer in order to restore it to a usable state. Whether this warping is due to internal strains, introduced at the foundry, or not, I can not say but regardless of how they are preheated and welded the average welder never seems to be quite sure of the outcome. Whether you have had this experience, Ed, I do not know but as I say, I have found it to be general. You can therefore imagine that I showed signs of real interest when I ran up against this fellow here who had found a way of overcoming this warping. How I discovered the trick is rather interesting too.

I had finished up my business and was just knocking around when I came across this particular shop. It was a very ordinary place but I noticed rather an unusual number of Ford motor heads stacked up on one side. I entered the shop and had quite a chat with the welder and we got rather chummy.

"You seem to be getting more than your share of motor heads," I remarked, "what kind of success are you having with them?"

"Finest ever, nary a one has ever come back," he answered.

"That's certainly a fine record," I commented, thinking to myself how often have I heard similar remarks only to find that the work was being taken to some other shop whenever a failure occurred.

"How about warping?" I ventured.

"Used to have all sorts of trouble until I studied out a little stunt of my own to overcome it. After that there has been nothing to it."

"What's the trick?" I asked.

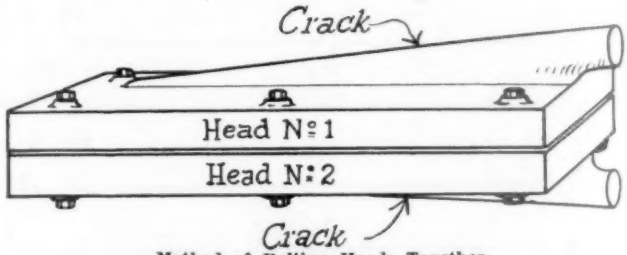
"Now, I don't know as we're ready to tell the world about it just yet," he smiled, "but you can see for yourself that we're getting by all right. Here's a straight edge; that pile over on that side has all been welded; give them the once over if you wish."

I did that little thing, Ed, and I'll swear they were all so near perfect that they sure looked like the work of a master.

I showed my admiration. How could I help it after seeing so many, many failures in the past? Says I to myself says I, "If this fellow has a heart at all I'm going to get this information" so I flattered him to the Queen's taste, commenting on the neatness and smoothness of the weld; the lack of "pin-holes"; apparent softness of the metal et al. but evidently to no avail.

"Come on old man! Why not loosen up on a stunt like that? Don't you know that you would be doing a great thing for the the Oxy-Acetylene Industry as a whole, if you tell your fellow welders of your findings? Why the boys from Maine to California would be mighty grateful to learn a stunt like this."

"It certainly sounds reasonable," he answered, "but I'm not exactly looking for gratitude. Here I've established a pretty good business and I'm getting even more than my share of the motor head business as you remarked when you came in just now. Why so? Just because I've gone in for that particular thing and have doped it out to make a success where the next fellow fails. If I were to give you this information it wouldn't be long before every lad in town would be doing it the same way and Blooie! my business would be all scattered and I wouldn't be any better than when I started."



Method of Bolting Heads Together.

"I wouldn't say that," I replied. "As a general rule the man that uses his head has the edge on the fellow that don't and just because you've conquered this problem is no sign that you are going to stop there. Men like you can't be kept down. You're bound to win."

After that I wished him every success and told him that while I was loath to go without having his dope, yet he was the doctor, so bidding him a merry "Cherio" I left him smiling and in a happy frame of mind.

You are probably wondering whether I got the information after all. I sure did! You know me, Ed, the old army doctors weren't pronouncing me blind when they said my eyes registered twenty-twenty. During my conversation with this fellow I noticed over on one of the tables, two heads bolted together face to face with six bolts. Sure enough, there was the solution. I didn't say anything to him but it was plain to see that I had discovered his method. With the heads bolted together they could both be preheated that way and first one side welded and then the other, care being taken to see that they were red hot and, of course a charcoal fire would be best. When finished welding, they could be left right in the fire and allowed to cool with the dying embers. What could be more simple, Ed? Yet it's sometimes the simple things that we overlook, isn't it? I'm no hand at making sketches, Ed, but perhaps you can check up the idea from the enclosure.

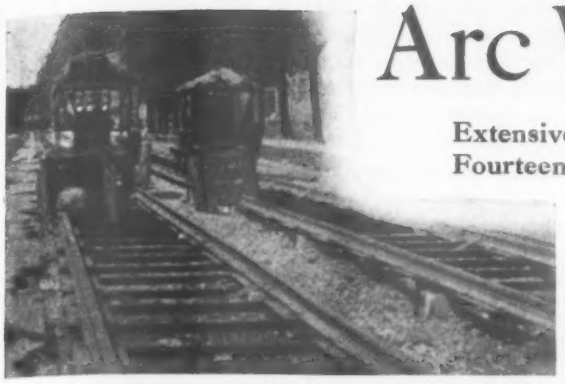
Yours, as ever,

Shep.

P. S.—I wish that you would try out this stunt as soon as possible and let me know what luck you have.

NEW TORCHWELD FOLDER

To assist dealers in advertising, the Torchweld Equipment Company, Chicago, has recently had printed a supply of envelope enclosures, advertising their line of welding and cutting outfits, and bearing the dealer's name and address at the bottom of the title page. The folder illustrates complete welding and cutting outfits in cases and with trucks, the decarbonizing outfit, the lead burning outfit, and the welding torch with cutting attachment.



Arc Welded Rail Joints

Extensive Construction Program in Detroit called for Use of Fourteen Welding Machines — All Joints and Bonds Welded

In the photograph at the left we see two operators making seam welds on rail joints. Bystanders and passers-by are protected from the harmful rays of the arc by large wood screens, which also serve to let the welder work without interruption. This is typical of the thoroughness with which the details of Detroit's construction program are worked out.

EARLY in the Spring of 1921 the city of Detroit began what is probably the most extensive program of street railway construction attempted in this country since the war. The city already has several miles of track of its own construction in operation, still more under construction, and a considerable mileage that has been purchased and rebuilt, or which will be purchased later. This year's program of purchase and construction indicates that transportation in Detroit will ultimately be a matter of municipal rather than a private enterprise.

In the construction of new track there is a marked effort to secure permanency, to conform to modern standards and to economize on labor by substituting efficient machinery as far as possible. The details of the welding of the rail joints as set forth below may be taken as typical of the thoroughness which characterized the organization of Detroit's construction program. H. M. Gould, electrical engineer, formerly of the Connecticut company, directed the rail welding and bonding and the overhead construction. H. P. Henover, construction engineer, assisted by W. R. Dunham, Jr., formerly engineer of way of the Connecticut Company, directed the track work.

All the joints were made by the metallic arc welding process and supplemented by the use of arc welded rail bonds. The welded joint has long ago been adopted as the most permanent form of joint as well as the most economical, contributing extra life and service to both trackage and rolling stock; and much can be done by welded bonds to secure extra good negative return circuits. Welding, then, is an important process in the construction and maintenance of street railways. Few industries can find such constant application of welding or such a variety of applications. For the work under discussion requisition was made for twelve two-electrode metallic arc welders and two resistance-type welders. It was necessary to use gasoline engine driven welding machinery for most of the work because overhead current was not available, the track being completed before the trolley wires were hung. The welders used had a capacity of 300 amperes at 35 volts, using approximately 20 volts at the arc. In Figure 1, two of these machines are shown in operation on a double track, one operator working on each rail. In the same photograph will be noted the use of "Danger" signs to warn bystanders against watching the arc. Every arc welder knows how painful and dangerous are the results of exposing the eyes to the rays of the electric arc, and all members of the welding crew are well aware of it, but the public has to learn such details by unpleasant experience sometimes. Wherever joint welding is done by the arc, it will be noticed that all members of the crew immediately turn their backs when the arc is struck, but bystanders and passengers on the front platform of a waiting car are fascinated by the spectacular sputter and glare of the novel operation, so they want to watch it. To protect them against their natural curiosity, three sided adjustable wood shields were made. A few small boards and a couple of pairs of hinges make a complete enough enclosure. Notches cut in the bottom of the end sections allow them to be fitted over rails and increase the stability of the shields. On each face is printed in large bold type the legend:

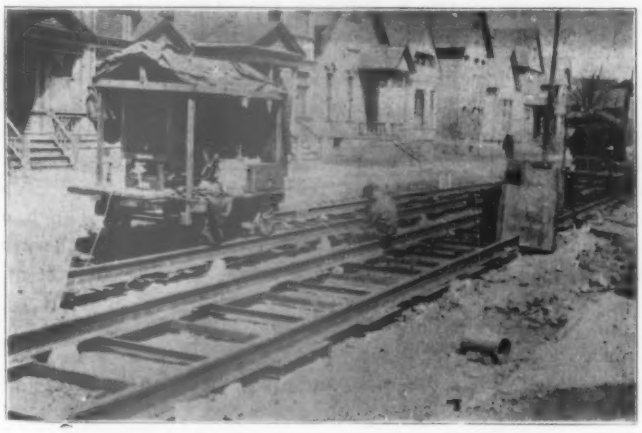


Fig. 1. Two Machines at Work on Double Track.

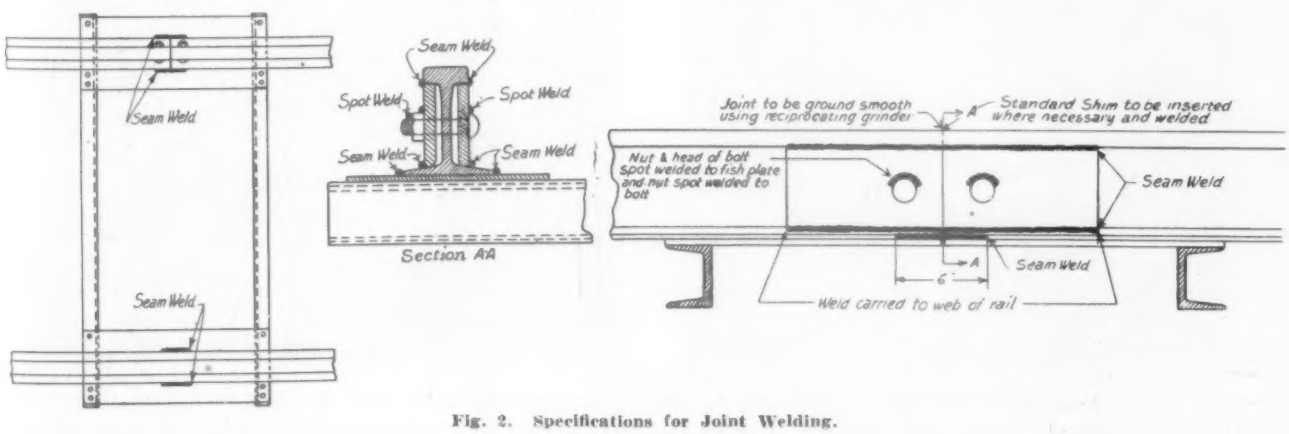


Fig. 2. Specifications for Joint Welding.

DANGER
DO NOT
WATCH ARC

Figure 8 gives a good idea of the simple and substantial construction of these shields.

Specifications of the standard Tee rail adopted for use thruout this construction called for open hearth steel of the following chemical composition:

Carbon	0.6 to 0.75%
Manganese	0.6 to 0.9%
Silicon	not over 0.2%
Phosphorus	not over 0.04%

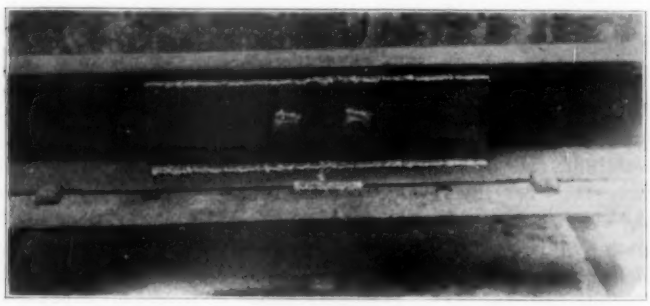


Fig. 3. Standard Joint Weld.

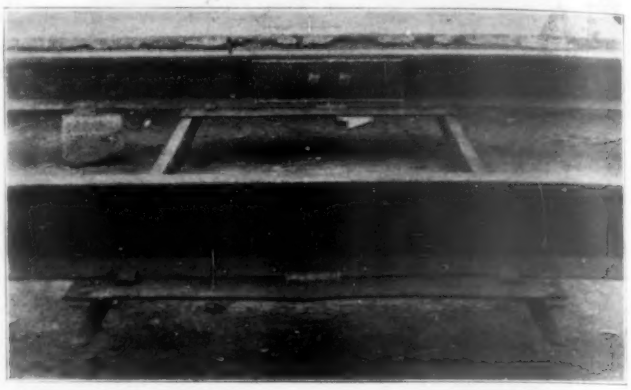


Fig. 4. Rail Opposite Joint Welded to Tie Plate.

Specifications of the standard splice bars for making rail joints called for the following chemical composition:

The steel shall be made by the open hearth process. The phosphorus content of the steel shall not exceed 0.04%; and the following physical properties: Grade "A" steel. Tensile strength 55,000 to 65,000 lbs. per square inch. Elongation in two inches not less than 25%. The test specimen shall bend cold flat on itself without fracture on the outside of the bent portion. Bars shall be smoothly rolled, true to templet and shall accurately fit the rails. The finished bar shall be free from all injurious defects and shall have a workmanlike finish.

Before welding the ties and rails were assembled and blocked up approximately to grade by means of concrete blocks made for this special purpose during the past winter. A perfect adjustment of grade and alignment is not possible so just before pouring the concrete foundation another final adjustment was made.

Standard joints between rails are made by welding splice bars, twenty inches long and three-fourths inch thick, to the ball and base of the rail. Splice bars are held in place for welding by two one-inch bolts. Figure 2 is from a blueprint giving specifications for standard joint welding for rails on steel ties. Seam welds are run the entire length of the splice bar, fusing it to the ball and base of the rail. The rails are welded together at the base on each side; and the base of the rail on each side is welded to the tie plate on a line opposite the line joining the centers of the bolts. The bolt head is fused with the splice bar by what is termed a "spot" weld in street railway work; and on the other side the nut is fused to the splice bar and to the bolt itself. Where joints are not tight, the specifications call for the insertion of a standard shim, which is to be welded in place. Figure 3 shows a completed joint on the inside of a rail. The rail joints are staggered and both sides of the base of the rail opposite a joint are also welded to the tie plate. This is done on both sides of the rail. Figure 4 shows a rail joint completed and the weld between the rail opposite and its tie plate.

Additional welding is used to perfect the electrical circuit. This is shown in detail in Figure 5. Beginning at the joint every other tie is welded to the base of the rail and on one tie per rail length located midway between joints the two tie plates are each spot welded at the four corners to the cross channels as well as to both sides of the bases of the two rails. A 0000 arc welded cross bond is installed between tracks every five hundred feet as shown in Figure 11. All this insures a perfect cross bond between rails and makes it practically impossible for an open to occur in the negative return circuit, for if every joint were broken there would still be an electrical by-pass around the joints through the intermediate welded ties and opposite rail.

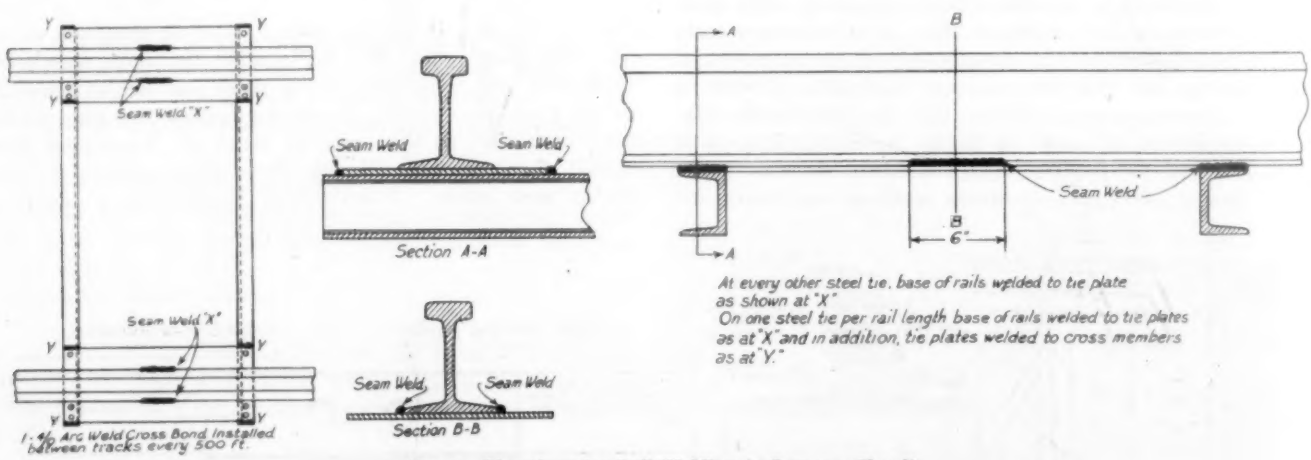

Y
Seam Weld "X"
Seam Weld
Seam Weld
Section A-A
Seam Weld "X"
Seam Weld
Seam Weld
Section B-B
1-4" Arc Weld Cross Bond installed between tracks every 500 ft.
A
B
B
6"
Seam Weld
At every other steel tie, base of rails welded to tie plate as shown at "X"
On one steel tie per rail length base of rails welded to tie plates as at "X" and in addition, tie plates welded to cross members as at "Y."

Fig. 5. Directions for Rail Welding to Improve Circuit.

Details of the welding required wherever wood tie construction occurs are shown in Figure 6. The joint welding is practically the same as in the steel tie construction. Section CC shows bolts and nuts spot welded on every tie rod on both sides of the rail in special work and guard rail curves. This is done on every third tie rod on tangent tracks. 0000 arc welded cross bonds are installed between tracks every thousand feet.

In the early stages of the construction of new trackage a series of unique tests were made to determine the temperature of the ball of the rail during the welding operation. For one of these tests holes were drilled in the ball of the rail, filled with oil, and thermometers were inserted in the oil. This test was not so easy to make, however, as the one shown in Figure 8, where thermometer bulbs are held in contact with the rail by large pads of putty. Figure 9 shows the thermometers in place while the welding is being done. The thermometers are disposed as shown in the diagram in Figure 7, and readings taken every five minutes. Various methods of welding were tried, sometimes on special work but usually on rails laid in the street. A close study of the test figures brings out the interesting fact that in only one case did the temperature of the rail rise as high as the temperature of boiling water. Following is an analysis of five of temperature tests made in this manner:

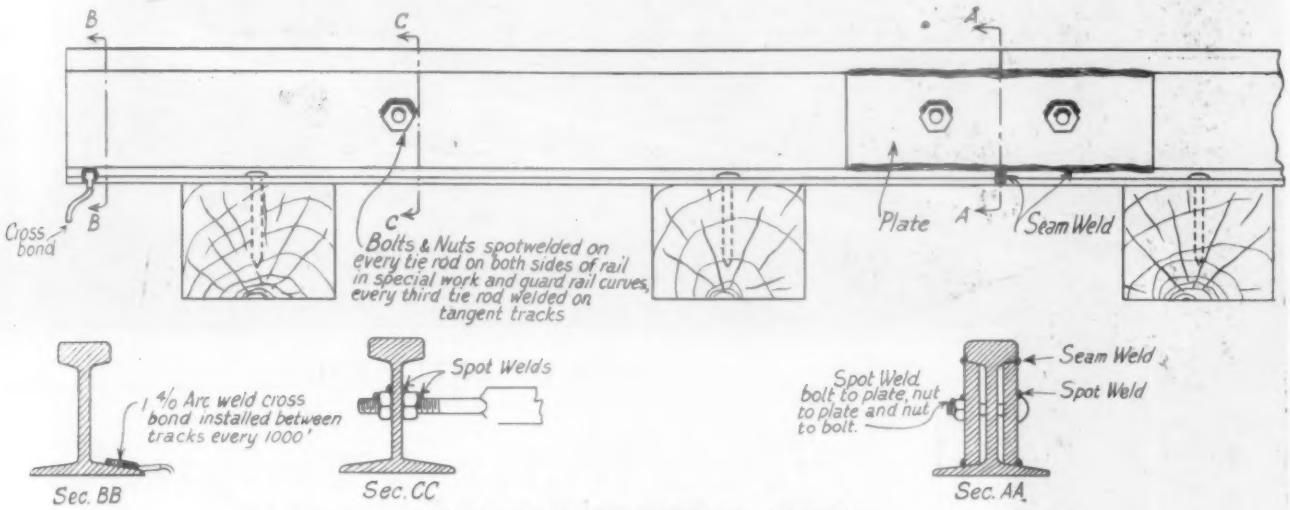

B
C
A
Cross bond
B
C
Bolts & Nuts spotwelded on every tie rod on both sides of rail in special work and guard rail curves, every third tie rod welded on tangent tracks
Plate
A
Seam Weld
1/0 Arc weld cross bond installed between tracks every 1000'
Spot Welds
Spot Weld bolt to plate, nut to plate and nut to bolt.
Seam Weld
Spot Weld
Sec. BB
Sec. CC
Sec. AA

Fig. 6. Joint Welding on Wood Tie Construction.

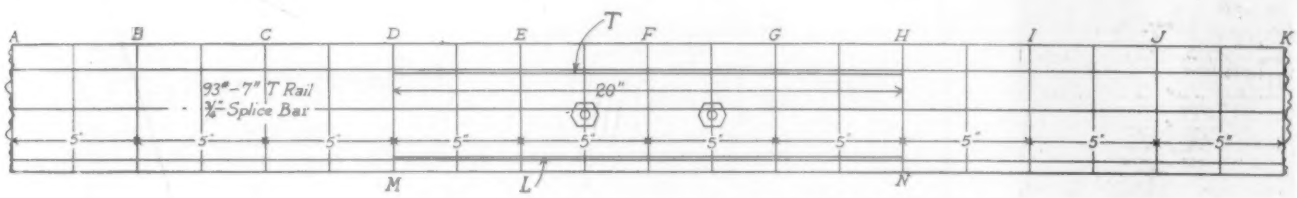


Fig. 7. Positions of Thermometers in Temperature Tests.

Test No. 1.

Time 3:50 to 4:50 P. M. Air temperature 68°.

Thermometers held in place by putty.

Two men welding. Test made on track laid in street.

Top seam welds made simultaneously, D to H, then bottom seams welds made simultaneously, M to N.

Maximum temperatures: A, 73.4°; D, 114.8°; F, 136.4°; H, 116.6°; K, 80.6°.

Total time, four seams, 15 minutes.

Test No. 2

Time 11:25 A. M. to 12:20 P. M. Air temperatures 77° to 84°.

Thermometers held in place by putty.

One man welding. Test made on track laid in street.

Welded top seams only, D to F, F to H on east side then D to F, F to H on west side.

Maximum temperatures: A, 104°; D, 158°; F, 199.4°; H, 165.2°; K, 109.4°.

Total time, two seams, 23 minutes.

Test No. 3

Time 10:25 to 12 A. M. Air temperature 69.8° to 86°.

Thermometer held in place by putty.

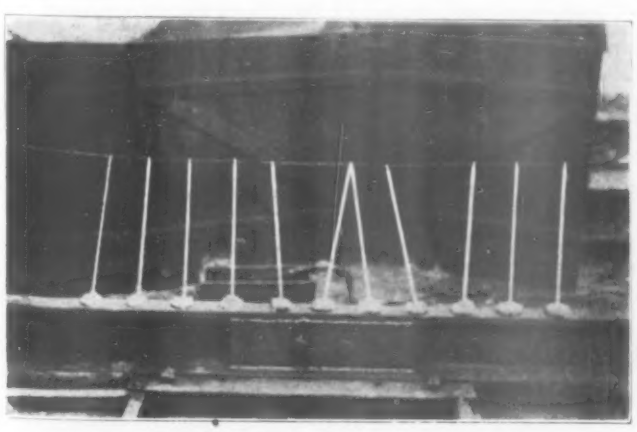


Fig. 8. Thermometers in Place After Welding.

Fig. 9. Test Made on Track Laid in Street.

One man welding. Test made on track laid in street.

Top seams welded, D to H and H to D, then bottom seams welded M to N and N to M.

Maximum temperatures A, 104°; D, 138.2°; F, 163.4°; H, 149°; K, 104°.

WELDING AND CUTTING APPARATUS

MEN OF EXPERIENCE

OXYGEN ACETYLENE APPARATUS SUPPLIES

National Welding Equipment Co.

APPARATUS FOR
WELDING AND CUTTING METALS

419 SOUTH STATE STREET

GENERATORS
CUTTERS
BLOW PIPES
WELDING RODS

COMPLETE PLANTS INSTALLED ANYWHERE
UNDER OUR OWN DIRECTION

SYRACUSE, N. Y.

September 2, 1921.

The Bastian Blessing Co.,
125 W. Austin Ave.,
Chicago, Ill. Att'n. Mr. Mills.

Dear Mr. Mills:

We wish to thank you for the prompt shipment that you made of our last order and assure you that this hearty cooperation is greatly appreciated.

Even if all makes of Oxy-acetylene apparatus were on a par, it would be very difficult for us to find a manufacturer whose service can be compared with the service you have shown us. We feel that you should know just why we have standardized on Rego apparatus.

When the National Welding Equipment Company was organized, the head of the company advised the writer that they were depending upon him to select the very best apparatus manufactured for their distribution and charged him to be most careful in his selection.

The writer immediately got in touch with various manufacturers of Oxy-acetylene Apparatus, advising them that he would visit their plants for the sole purpose of testing and trying out their equipment. We tried and tested the various makes not only in the factories themselves, but also in our experimental shops, giving them all the same trial before making a selection. We do not hesitate to state that Rego proved itself to be designed scientifically and constructed substantially.

Our locality is spotted with satisfied users of Rego Equipment who are ready to back us up in what we have to say.

Again assuring you of our appreciation for the cooperation extended by your good house, we beg to remain

Very truly yours,

NATIONAL WELDING EQUIPMENT CO.

HS/F BY Henry J. Sommer Mgr.

THE BASTIAN BLESSING COMPANY
WEST AUSTIN AVENUE AT LA SALLE STREET CHICAGO.

WELDING AND CUTTING APPARATUS

"Designed Scientifically and Constructed Substantially"

says Harry Solomon, of Rego apparatus.

He ***knows*** because he has had eight years' experience with other apparatus.

Do you ***know*** the principle of correct torch design, or are you just taking the "other fellow's" word for it?

It is simple to understand if you have the ***"Facts." Send for a copy!***

THE BASTIAN BLESSING COMPANY
WEST AUSTIN AVENUE AT LA SALLE STREET CHICAGO.

Total time, four seams, 35.5 minutes.

Test No. 4

Time 12:45 to 2:15 P. M. Air temperature 89.6° to 91.4°.

Thermometer held in place by putty.

One man welding. Test made on special joint.

Six inches in center of top seam welded first, then six inches of bottom seam starting one inch from end of splice bar, then six inches of bottom seam starting thirteen inches from same end, leaving six inches unwelded in center. Process repeated on other side of rail.

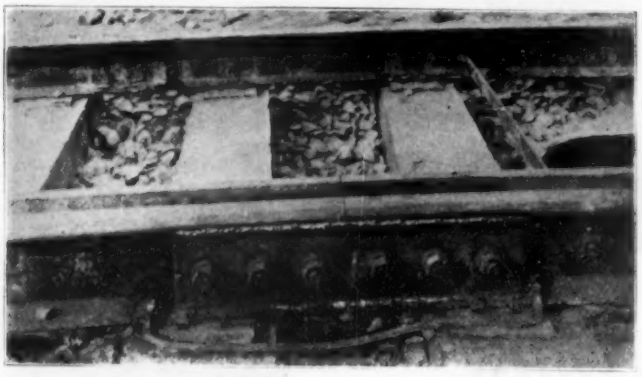


Fig. 10. 0000 Bond Around Six-Bolt Fish Plate.

Maximum temperatures: Left end of splice bar, 150.8°; center of splice bar, 197.6°; right end of splice bar, 138.2°.

Total time, six six-inch seams, twenty minutes.

Test No. 5

Time 1:40 to 4:20 P. M. Air temperature 93.2° to 19.4°.

Thermometers inserted in holes drilled in ball of rail. These holes were filled with oil.

One man welding. Test made on special joint.

Top seams welded, then bottom seams, all welds carried in same direction.

Maximum temperatures: Left end of splice bar, 185°; center of splice bar, 203°; point midway between center and right end of splice bar, 239°; right end of splice bar, 222.8°.

Fig. 11. Rails are Bonded in This Manner Every 500 Feet.

Total time, four seams, one hour and nine minutes. Maximum temperature recorded in this test was reached as second top seam weld was finished.

Note: All temperatures given are Fahrenheit scale. All tests were made on 93 lb. 7-inch "T" rails, joined by ¾-inch splice bars of standard specification. Figue 7 gives plan of tests 1, 2 and 3.

In special work all joints are made with six bolt fishplates, as shown in Figure 10. A 0000 bond is attached to the rail at each end of the fishplate, or, in case there is not room enough, a short V bond is used and welded to the base of the rail. The use of this extra bond is justified because the joint is more liable to fail than joints in tangent track, and there is only a small expense involved in taking this extra precaution against a broken circuit. It also gives the wood tie construction in the special work the same electrical capacity as the steel tie construction on tangent tracks.

In addition to the complete bonding of the rail joints, special work layouts are shunted by an unusual amount of copper. Figure 11 is a sketch of a typical double track intersection with the extra bonding indicated by heavy black lines. The two rails of each of the eight tracks approaching the intersection are bonded together with three 0000 standard copper arc weld bonds. The inner rails of the two tracks at the four approaches are similarly bonded with two 0000 arc weld bonds.

The mid point of the three bonds between the rails of each track is then connected to the similar cross bonds of the same track at the opposite side of the special work by a 1,000,000 circ. mil stranded bare copper cable, the connection being made with soldered joints which are painted with black insulating

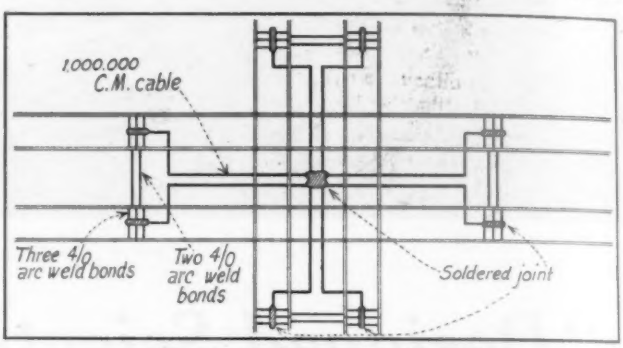


Fig. 12. Bonding on Special Work.

paint and wrapped. The entire cables and cross bonds are also painted. There are thus four of these 1,000,000 circ. mil cables, two in each direction, intersecting at the center of the special work layout, and they are all tied together at this point in a soldered joint. These cross cables are laid in the devil strip in a wood trough filled with a mixture of 75% pitch and 25% tar and a small amount of fine gravel. At outlying points the same system of bonding special work layouts is used except that the size of the crosscables is reduced. A sketch of this bonding scheme is reproduced herewith, from which an understanding of the scheme can more quickly be obtained than from the description. It makes it possible to lift out an entire layout without disturbing the return circuit.

So much for the extensive use of welding in the actual construction. It should also be borne in mind that the arc welder working alongside of other heavy machinery, such as steam shovels, cranes, concrete mixers, tractors, etc., can save hundreds of dollars by making quick repairs of broken parts, often without taking the machinery apart. The presence of the welder, in fact, insures against many expensive breakdown delays.

The Auto Welding Co., of Lawrence, Mass., have plans in progress for a one-story, 53x92-foot shop.

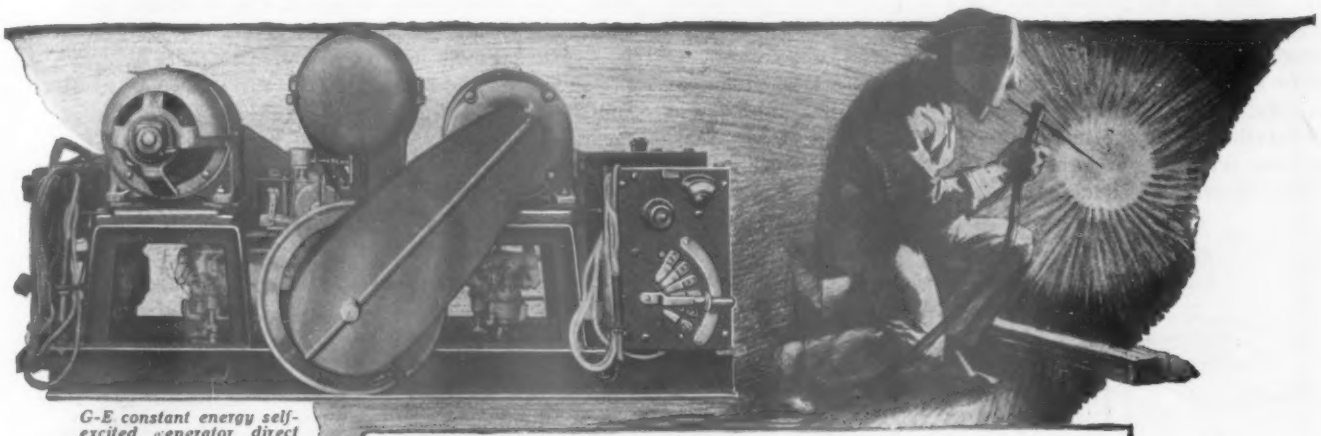
The Welded Products Mfg. Co. is the new name for the Electric Welding & Mfg. Co., 145 Clinton Street, Milwaukee. The new name better designates the nature of the business of the company.

NEW CALCIUM CARBIDE STORAGE ORDINANCE PASSED IN HOBOKEN, NEW JERSEY

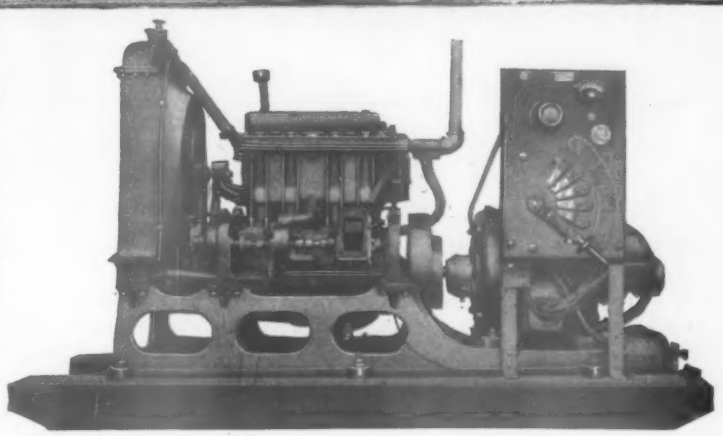
Users of Calcium Carbide in the city of Hoboken, New Jersey, will find it valuable to inform themselves in regard to an ordinance recently passed in that city. This ordinance covers the use and storage of carbide and consequently will affect a great many welding shops and other repair establishments which use carbide in generating acetylene.

"Practical Applications of the Electric Arc Welding Process" was the subject of a paper read by E. Wanamaker, Electrical Engineer, Rock Island Lines, before a meeting of the American Welding Society, Metropolitan Section, September 20. An interesting feature of the paper was a complete outline of a general plan for handling welding specifications in railroad work.

Apparatus which makes arc welding possible where there is no electric power service improves metal working on many a job



G-E constant energy self-excited generator direct connected to 20 h.-p. gasoline or kerosene engine, two cylinder horizontal opposed four cycle tractor type. Single or two operator sets.



Constant energy self-excited generator direct connected to 20 h.-p. gasoline engine, four cylinder vertical automobile type. Single operator sets only.

These G-E welding sets will do satisfactory work anywhere

The arc welding field, formerly limited by electric power lines, has been extended. G-E Arc Welding Sets, driven by gasoline or kerosene engine, have removed all limits.

On a tug or barge one of these welding sets can be easily used to repair ships lying at anchor. Carried on a small truck it will go into oil fields, lumber or mining regions—or villages far from a power line. Repair men using these G-E welding sets are extending their business and increasing their profits.

With one of these welding sets, an isolated industrial plant employing a welder who knows his business, can profit by all the advantages of arc welding—swift repairs, defective parts reclaimed, worn metal built up for new service, and a number of other benefits—all economically secured.

Further information describing G-E Welding Equipment will be sent on request to our nearest office.

General Electric Company

General Office Schenectady, N.Y.

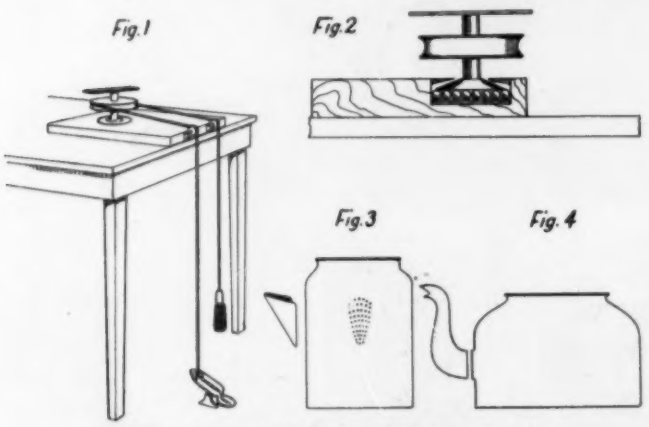
Sales Offices in all large cities

43B-643

WELDING ALUMINUM WARE

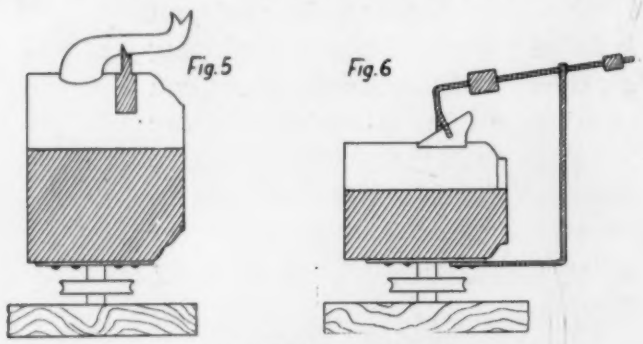
How the Use of a Few Simple Devices Speeds up Production Work and Results in a Fine Looking Product

USUALLY when a manufacturer incorporates welded joints in his product he talks to prospective customers about the strength of the joint, the advantage of making a single piece of metal out of two sections. Many products have been vastly improved, at a reduction in cost of manufacture, by substituting welding for riveted joints or threaded connections. In the manufacture of aluminum kitchenware, another feature is brought out—the appearance of the welded joint. Rows of glistening pots and kettles on the shelves of the hardware dealer are a strong temptation to every housekeeper; it is so easy to imagine the pleasure of handling the shiny, spotless utensils in the kitchen. Aluminum is an ideal metal for such utensils because of its comparatively low cost, its lightness, its non-rusting qualities and its fine appearance. Consequently, it is very popular.



Welding Table and Details of Revolving Stand.

Two of the most indispensable kitchen utensils have been considerably improved by our simple welding operation. They are the teakettle and the coffee percolator. These were formerly made by "clinching" the spout to the body, a method that produced the necessary watertight joint but left a tiny crack which in a short time took the appearance of a small black line around the seam. It could not be kept absolutely clean.



How Jigs Hold Parts in Place.

For several years the "clinched" spout has been replaced by the welded spout, and the production of the latter has been developed to the point where the appearance of the finished article leaves nothing to be desired. It was not an easy process at the start, for sheet metal has a strong tendency to warp under the influence of the welding flame, and aluminum in any form is easily spoiled by the application of too much heat. Persistent effort solved all the problems, however, and today the dealer can display to his trade a kettle or percolator which shows not the slightest trace of a joint between the spout and the body. In fact, there is no joint—the spout and the body have become a single piece under the magic of the oxy-acetylene flame. If the spout is banged against the oven of the gas stove, or against the faucet over the sink, it cannot break loose, for there is no place where a break can start. The welder has given the dealer a strong selling point.

This welding operation is neither slow nor expensive compared to former methods of assembly. In the factory of the Aluminum Products Company, of LaGrange, Illinois, makers of the "Lifetime" brand of aluminum cooking utensils, and pioneers in the art of welding aluminum products, production welding plays an important role. The remarkable feature of this welding department is the extreme simplicity of apparatus and procedure required to turn out such excellent results.

Fig. 7. As They Come from the Torch.

The welding table (Figure 1) is equipped with a revolving stand to which can be fitted suitable jigs for holding the parts in place for the welder. This revolving stand (shown in detail in Figure 2) twists back and forth on ball bearings so that its motion is very smooth and easy. Motion is controlled by a fixed pedal and a counterweight. This easy motion is an important factor in securing perfect welds, for if the stand should stick and then jump the metal would be burned through in spots and portions of the seam would have to be gone over twice.

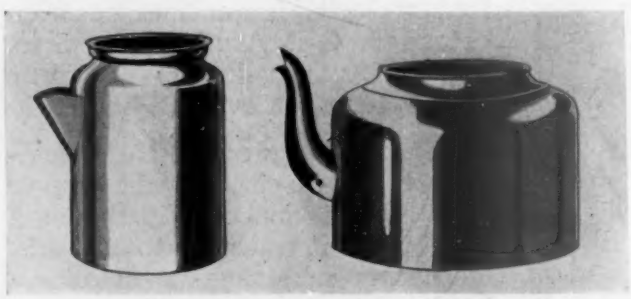


Fig. 8. After Polishing Welds.

Manganese sheet aluminum is used in the manufacture of the "Lifetime" utensils. It is claimed that a small quantity of manganese stiffens the utensils so they will not bend or

Research!

Metallurgical research in welding processes must be conducted only by the most expert metallurgists and chemists if absolute facts are to be determined.

The Armco Laboratory is one of the most perfectly equipped in the world. It is constantly investigating welds. It has proved beyond question that welds produced with PAGE-ARMCO Welding Rods and Electrodes, **most consistently** approach the combined **strength, ductility** and **general characteristics** of mild steel base metal plates, etc.

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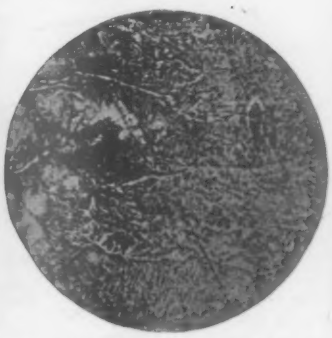
Photomicrograph of acetylene weld.



Photomicrograph of electric weld.

Microscopic examination where specimens are magnified from 100 to 1,000 diameters.

PAGE-ARMCO
WELDING RODS and ELECTRODES

buckle easily but are hard, dense and rigid. The filler rod used for welding them is pure rolled aluminum wire.

Figures 3 and 4 show how simply the percolators and kettles are prepared for welding. The percolator spout is stamped and bent to fit snugly against the body, and the hole in the body of the kettle is flanged outward slightly so that the spout fits over it. A holding jig for each utensil is made by cutting a similar utensil in half and bolting the piece to the revolving stand. An arm holding a weighted fork (Figure 5) provides sufficient pressure to keep percolator spouts in place, and the kettle spout is held by a light support underneath (Figure 5).

A powdered flux dissolved in water is used to prevent oxidation. The welder uses a small torch and adjusts the flame so that it is slightly carbonizing, dips his wire into the flux solution, brushes the seam and the wire with the flame and starts to melt the metal directly before him. As soon as fusion starts he presses on the pedal and the entire seam passes under the flame. A quick pass with the flame over the end of the seam gives a finishing touch and the welder is ready for another piece. The actual welding time has been about fourteen seconds and the whole cycle of operations on one kettle has been less than thirty-five seconds. There is no warping or buckling nor any ridge of added metal, just a thin dark film or slag over the weld, and a slight discoloration where the flame has played over the metal.

Figure 7 gives a good idea of the appearance of a kettle and percolator as they come from the welder. A few seconds are required for "buffing up" and the joints then have the smooth polished appearance shown in Figure 8.

Practice in adjusting and handling the flame is the chief requisite to success in this operation. The ingenious holding devices and the simple method of handling eliminate all the difficulties which would naturally expect to encounter in such delicate and particular work. The welder specializes on this one class of work and becomes expert in a short time so that spoilage on account of warping or burning is practically unknown.

FORGING ARC WELDS

Editor:

In the August issue of *The Welding Engineer* we note the article by Mr. O. H. Escholz on the effect of forging of arc deposited metal and arc welds.

In this connection we believe the results of some tests on welds made upon alloy steel will be of interest to your readers. These welds were made in connection with the study of the feasibility of welding a certain structure of alloy steel.

This steel was not analyzed by us for these tests but was of the class having approximately the following analysis: Carbon, 0.70 to 0.85; Chromium, 0.65. The specimens were made from forge trimmings and were forged to the shapes shown in the accompanying photographs.

The stressed section was approximately one-quarter by three-quarters inches, the exact section of each weld is given by the figures in the accompanying certificates. The welds were all ground to the section of the adjacent base metal except in the case of the two which were forged.

Specimens Nos. 8 to 12 inclusive were ground on both sides to approximately 45 degrees. They were welded with a covered, eighth-inch alloy welding wire. The specimens were given the standard heat treatment for steel of this analysis.

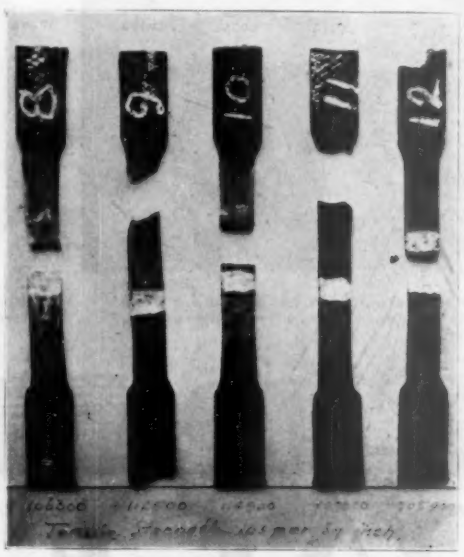
Tensile tests were made in a Riehle Testing Machine and were certified to by Smith, Emery & Company in the accompanying reports. It should be noted that the tensile values, 105,900 to 114,900 pounds per square inch, were obtained upon UNFORGED welds. The photograph of these specimens shows the position of the break in each case.

TABLE OF TEST RESULTS

Laboratory Number	No. 8 60641	No. 9 60642	No. 10 60643	No. 11 60644	No. 12 60645	No. 13 60804	No.14 60805
Description	WELDED SAMPLES					STANDARD	
Actual Dimensions	.700x.290	.735x.269	.723x.284	.694x.281	.721x.292	.260x.714	.255x.707
Actual area sq. in.	.2030	.1977	.2053	.1950	.2105	.1856	.1800
Maximum load, lbs.	21580	22250	23580	21420	22290	29290	26320
Tensile strength, lbs., per sq. in.	106300	112500	114900	109800	105900	157800	146200
Fracture	Silky	Silky	Silky	Silky	Silky	Silky	Silky

NOTE—Welds were all ground for testing to the same section as the adjacent part of the specimen.
Specimens Nos. 8, 9, 10 and 11 broke outside of weld. Specimen No. 12 broke partially in weld and partially in adjacent metal.
Specimens were marked "alloy steel" and were welded with special covered welding rods.
All specimens were heat-treated after welding.

As it was necessary to know the effect of forging the two specimens Nos. 13 and 14 were prepared, as shown in the photographs in their various stages. These welds were made as before but of approximately twice the former cross section. The surface of the welds were ground off sufficiently to remove irregularities of contour, after which they were forged to the uniform cross section given in the report. The heat



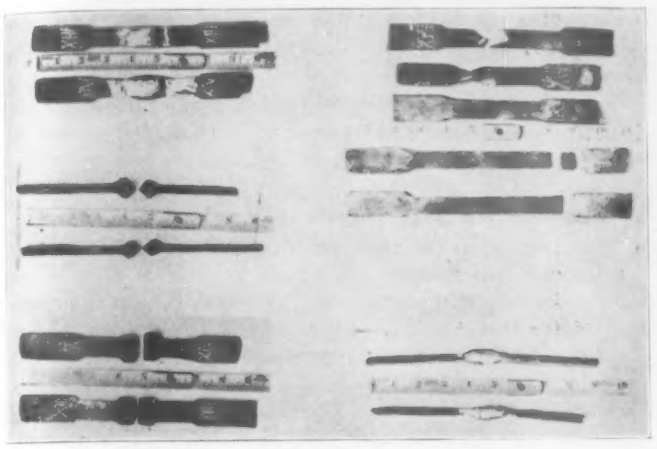
Specimens 8 to 12.

treatment differed slightly from that of the preceding specimens.

It will be noted that these specimens also broke outside the welded sections.

Since all the specimens broke in the base metal, these tests constitute a test of this steel rather than an ultimate test of the welds themselves, which may be considerably stronger.

In as much as the steel specimens were all forged before welding and the fractures were in the base metal, no con-



Specimens 13 and 14.

clusions can be drawn as to the beneficial effects of forging. The vital point in our case being that the welds were not injured by ordinary smith's forging.

The difference between Nos. 13 and 14 and Nos. 8 to 12 inclusive is undoubtedly due to the difference in heat treatment.

While no conclusions can be drawn as to the benefits of forging, it will be noted that the values are considerably higher than those reported by Mr. Escholz for either forged or unforged welds.

Yours very truly,

R. E. Frickey.
Kenneth V. Laird

A WELDED LOCOMOTIVE TENDER TANK

By J. W. Murphy

About six months ago, the Boston & Albany built at its West Springfield shops a tender tank of 8,000 gallons capacity, which was constructed entirely by welding the parts together by the electric arc process. So far as is known, this is the first departure from the customary riveted type construction for tender tanks.

Considerable experience had been gained with electric welding, particularly in boiler work, and in view of the successful results obtained and the adaptability of this process for welding seams of tanks, it was decided to construct a complete tank by electric arc welding. In the case of a riveted joint, considerable time is required for laying out and punching rivet holes and caulking. This work is not necessary in the case of electrically welded joints. Riveted joints cannot equal in strength the solid plate on account of the loss of metal at rivet holes, but welded joints if properly made have the strength of solid plate. It is recognized that the welded joint is strong and reliable and in the case of tank work there is the added advantage of freedom from leakage.

The electric welding process is superior to the oxy-acetylene process for certain kinds of work and is peculiarly adaptable for joining plates and welding seams. Oxy-acetylene welding can be used successfully in many kinds of repair work, but it is difficult to weld steel plates or sheets by this process on account of buckling and bulging produced by the heat.

The manner in which the sheets were welded to the tank angles is shown by Fig. 1. This is a satisfactory method as the welding can be done readily at reasonable cost and the strength of the joint is in excess of that usually obtained by the riveted type of construction. The side plates are butt-welded and the tank braces and splash plates are afterwards securely welded to the side sheets. The whole construction results in a water-tight tank of good appearance and great strength.

In assembling the various parts of the tank, approximately 1,200 linear feet of welding was done. The following tabulation shows the welding work in detail:

Butt-welded seams ¼ in. plate	95 ft.
8 Reinforcing tees, 3½ in. by 3½ in. by ⅜ in.	550 ft.
10 Tank angles, 2½ in. by 2½ in. by ⅜ in.	410 ft.
23 Side tees, 3½ in. by 3½ in. by ⅜ in.	120 ft.
Beading at coal side	25 ft.
Total linear feet of welding	1,200 ft.

The safety appliances and tank lugs are riveted to the sheet. The completed tank is 26 ft. long, 10 ft. wide and 5 ft. 2 in.

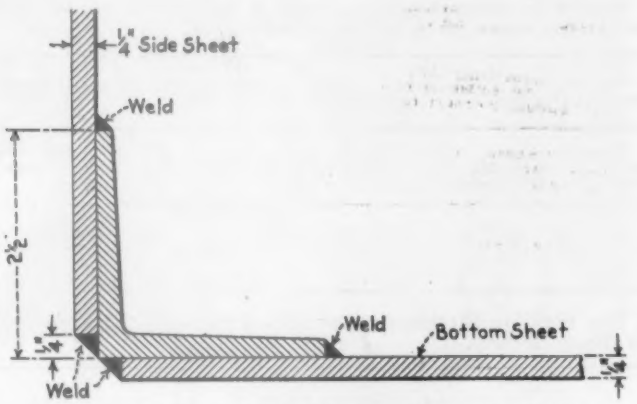


Fig. 1—Detail of Joint Between Angle and Sheets

Fig. 1. Details of Joint Between Angle and Sheets.

high, having a capacity of 8,000 gallons of water and 12 tons of coal. It is supported on a cast steel underframe and is used with a Pacific type locomotive in passenger service. The photograph shows the appearance of the completed tank, the absence of rivet heads being particularly noticeable.

The welded method of construction eliminates the necessity of punching rivet holes in sheets, tees and angles and there appears to be less likelihood of leaks developing in service. It is expected, therefore, that the cost of maintenance will be reduced. The welded tank has been in service for about six months and no defects of any kind have developed. Those who have had experience with the welded tender tank feel confident that this type will gradually supplant the customary riveted construction.—*Railway Mechanical Engineer.*

QUASI-ARC WELDTRODE COMPANY, OF PEEKSILL, N. Y., IN NEW BUILDING

The Quasi-Arc Weldtrode Co., formerly of Atlantic Avenue and Warwick Street, Brooklyn, have recently moved to their new quarters at 114 Hudson Avenue, Peekskill, N. Y., where they will be at home in the future. Their new location is adjacent to both the New York Central Railroad and the Hudson River piers which facilities will provide for convenient disposal of the company's products.

The new works will also be completely equipped for the manufacture of all arc-welding accessories and for the building of their entire line of welding apparatus including controllers for both alternating and direct current, welding generators driven by belt, direct connected motor or gas engine.

The Welding Engineer

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The Annual Harvest of Cheer

WHEN the time comes for the farmer to collect for the fruits of his year of labor the public begins to chase away the glooms and talk about how good business is going to be. The fall of 1921 is no exception, for the general attitude toward the future is rapidly growin more optimistic. Secretary of Agriculture Henry C. Wallace speaks of the increasing buying power of the farmer as a clear indication of improvement and predicts that this purchasing power will be utilized to the benefit of all. Another general indication of improvement is found in the announcement that the United States Steel corporation has voted to use $10,000,000 for the extension of its plants to provide work for employes who are now idle. It is probable that other industries will follow this example and use part of their accumulated reserve to furnish employment to those who need it.

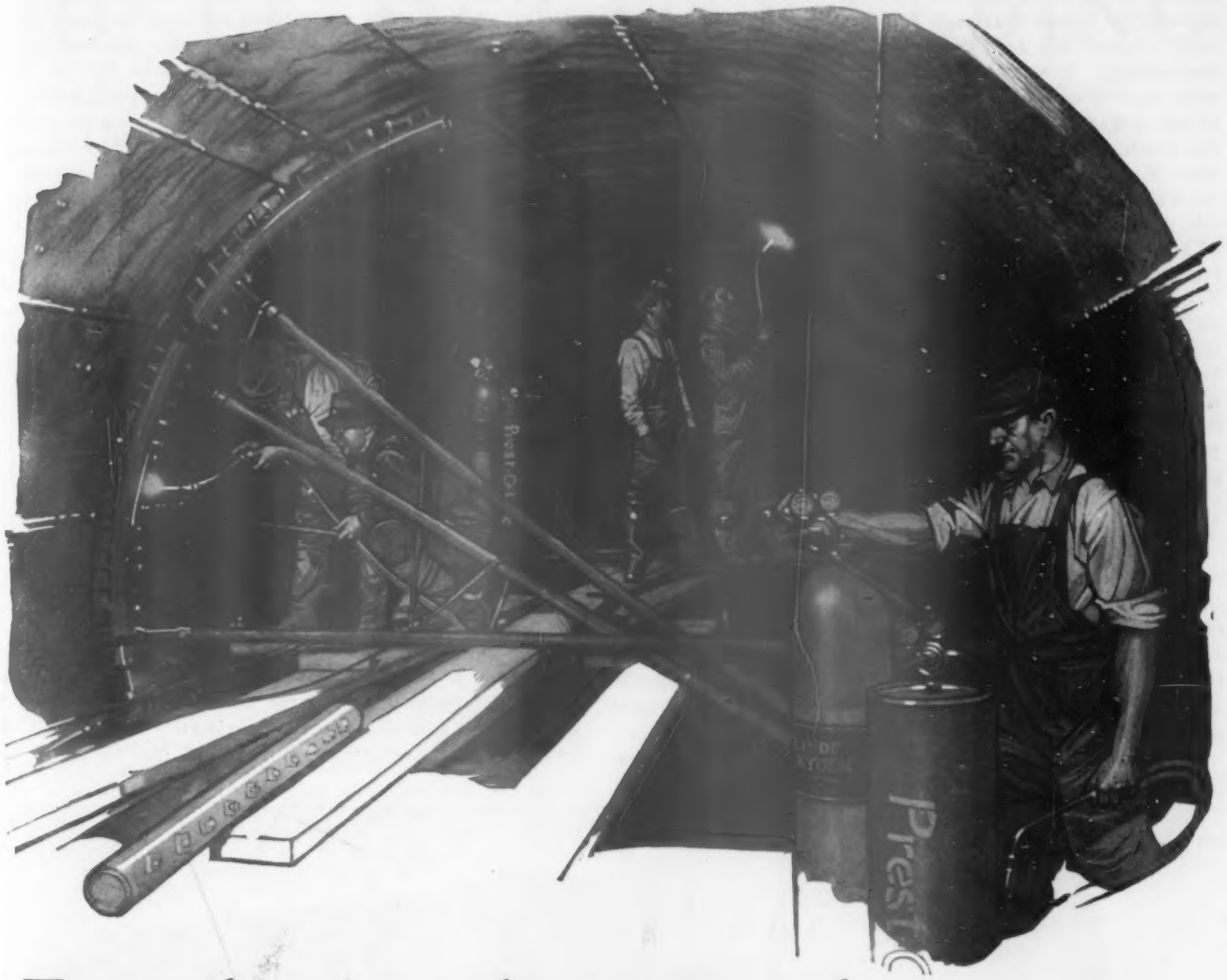
An Elaborate Welding Program

NEW track construction started by the city of Detroit this summer provided jobs for over a score of electric arc welders for about three months. Welded construction was adopted for two reasons; to give stronger joints and to improve the electrical circuit. It is especially interesting to note how many welds can be used to advantage on street railway track. Here is an exceptionally large market for welding equipment and supplies, with the buyers showing an increasing interest in the possibilities of the process.

What Is An Expert Welder?

A CORRESPONDENT raises this question, without venturing to nominate himself as the answer. Experts are indeed rare and hard to find. Fortunately the run of work does not require expert attention. The word "expert" is, however, one to be used with caution, for when expert welding is promised and the weld fails, not only the expert, but also the welding process acquires a bit of bad reputation. It is safer, and altogether as effective to guarantee the work, as it is to put the "expert" label on it. A customer will take back a guaranteed job that has failed and go away thoroughly satisfied when the failure has been made good, but he will pass up welding for all time once an "expert" has made a fizzle of a simple job.

A member of the American Welding Society writes: "I would like to mention my opinion on the same subject, namely, 'what is an expert welder?' I am sorry to say that the term 'Expert Welding done here' is a real drawback to the welding game. As a pioneer in commercial welding with some fifteen years practical welding experience I have run across people who would not tolerate welding under any circumstances and if you ask them why they will tell you, 'I got an expert welder from such a place to do a job for me and when he left the yard if fell in two again, and I have no faith in the process anymore. If an expert can't make a bit of a job stand more than a day or two it can't be any good.' I have met people like this both in this country and abroad, and when I have tried to explain to them that the job could be done successfully they have told me that they want no more welding; they are through with it. Another thing, it is a foolish idea for a welder to get it into his head that he is an expert, even though he be a good man on welding. For instance, I would not like to say I was an expert welder though I have had a good all around run in the welding game. Any welder knows that it makes no difference how good a man may be he is apt to run up against it when he least expects it and sometimes over a very simple looking job. Very often this occurs in a garage where they are not equipped for all classes of welding, such as a man may expect to get in a jobbing shop and if a man is slow in handling the job the result is that the customer thinks to himself this is a very slow process considering they are



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experts at it. These are the little things that go against the process. I believe that such signs as 'Expert Welding Done Here' should not be exhibited unless they add 'All Work Guaranteed.' It looks a little better then and gives the garage man more foundation for his advertisement. I would like to ask any welder who considers himself pretty well up in the game, if he has ever worked as a welder under a foreman or superintendent who has neither practice nor theory on welding. I am sorry to say I have run up against this sort of thing in my present locality, where a man is in charge of a modern welding shop that does a great amount of welding and employs about a dozen hands, welders and helpers. The man in question hangs around the job and insists on having his foolish ideas put into operation, knowing quite well that the welder on the job is capable of handling it. This sort of thing is very hard to stand for, when you know your business. All I can say about it is that this man is getting his experience at somebody else's expense, but what I would like to know is this—how do they get the job?"

ERA OF THE WELDED TANK

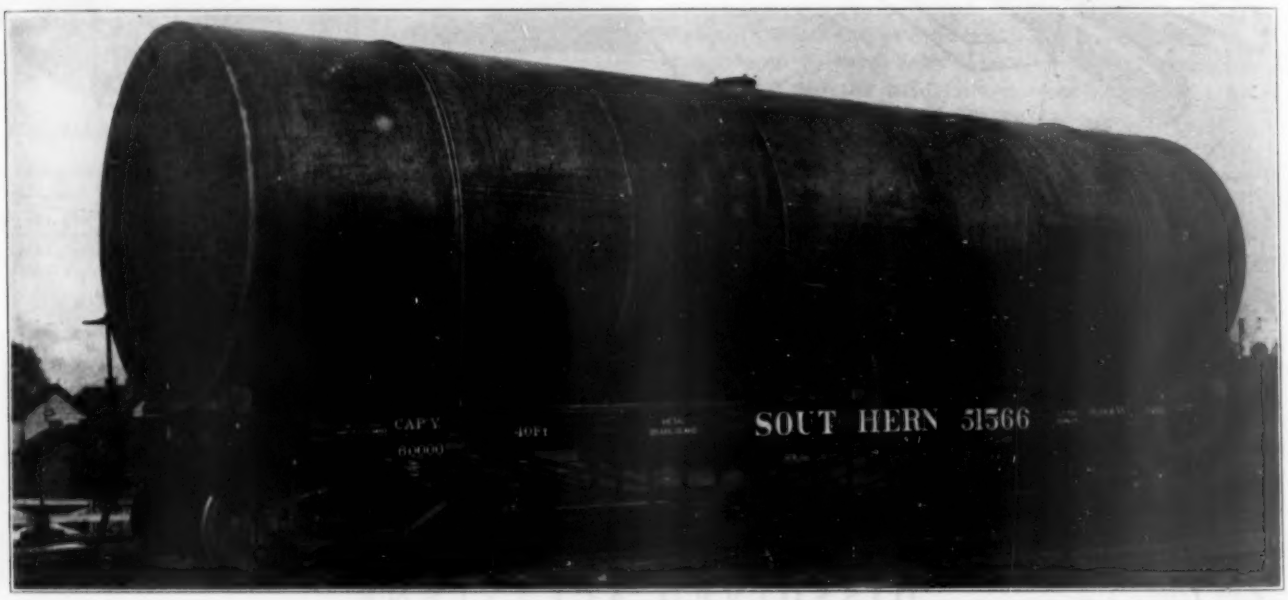
Oxy-acetylene welding is more and more superseding riveted construction in fabrication of metal tanks owing to the greater economy of manufacture and because the gas welded seam is demonstratably stronger than riveted jointing, not only with respect to its capacity for resisting internal pressure, but as well because the joints are inherently tighter than the most perfectly caulked riveted joints.

The tendency in favor of the welded tank was at first confined to tanks of relatively small capacity—a natural result of human conservatism in cautiously feeling the way to ultimate development in new fields of endeavor. Thus, the first steam engines were small, and more recently we have seen the fragile first models of aircrafts give way to larger and sturdier construction, until we look back across the space of even a few years with a smile at the limited boundaries that so recently marked the outposts of aeronautical vision. So with the welded tank, the relatively tiny vessels that first engaged engineering attention are now completely overshadowed by the larger construction of today. And, measured by the not remote future, the welder tanks we now regard as large are themselves but pygmies.

The tank shown in the illustration is not an example of the largest welded tanks made today. There has been one tank fabricated of nearly four times this tank's capacity, and there is a standard line of tanks manufactured by the Welded Products Co., of Birmingham, Ala., that exceeds the capacity of the tank shown by a thousand gallons. But the tank illustrated is presented as typical construction of its kind, and was selected because of certain interesting details connected with its fabrication and the problem of handling it in loading upon the flat car shown in the picture.

The specifications called for a tank 10 feet in diameter by 38½ feet in length (approximate capacity 24,000 gallons), built of $\frac{7}{16}$-inch shells in the body and ¼-inch plate in the heads. It will be noted that there were eight circumferential seams with the longitudinal seams arranged alternately, three of which are visible in the picture and four (not visible in the picture) being diametrically opposite. The heads are fabricated of five pieces joined by the two long and two short welds. The seams are all butt welds, built up on the outside to afford added strength. The sheets were chamfered at the joints to insure penetration of the flame and filling material. A flanged manhole, also made with the blowpipe is seen at the top center of the tank. The tank was tested to an internal pressure four times greater than any load it would be subjected to in service and all seams were oil tight.

In loading this tank on the car a large crane was used. This made it necessary to pick up the tank in the center by two cables running around the body and held apart by timbers, making a basket effect approximately 8 feet long. This, however, left an overhang of about 15 feet on either end—too much, considering the thin material of which the body was constructed, unless some further support were provided. This was accomplished by welding a plate on each end at the top to admit running turnbuckle bars from end to end. This was done, blocks being placed between the bars and the tank so as to form an arch. If this precaution had not been adopted the tank might have buckled of its own weight when lifted in loading. Even under such distortion it is probable that the welded covers would not have opened, as there are numerous cases of record in which oxy-acetylene welded tanks in fires and wrecks have been crushed by an exterior impact without in the least impairing the oil tightness of the joints.



24,000 Gallon Tank Welded by the Oxy-Acetylene Process.

MONEL METAL WELDING*

General Principles That Must Be Observed in the Welding of This Difficult Metal and Special Instructions for Rods and Sheets

By Michael Dzamba†

INTRODUCTORY

MONEL Metal, like most common metals, can easily be welded by following closely the standard welding practice, but good results cannot be obtained unless a few simple precautions are taken. Different metals, when molten, possess different characteristics, and in order to understand these peculiarities the operator should thoroughly familiarize himself with the composition as well as the physical properties of a metal before starting to weld it for the first time. The following paragraph will therefore be of material assistance to the operator in welding Monel Metal.

Monel Metal is an alloy of nickel and copper, containing about 67 per cent nickel, 28 per cent copper and 5 per cent of other elements. This remaining 5 per cent consists partly of iron and partly of manganese, silicon and carbon introduced in the process of refining.

Monel Metal is produced in such forms as wire rod, rounds, squares, hexagons, flats, sheets and castings. In the rolled form it tests as high as 100,000 lbs. per square inch, while the cast form is not quite as strong, having a tensile strength of 65,000 lbs. per square inch. The melting point of Monel Metal is 1360 deg. C. Its coefficient of expansion is .000014 per one degree Centigrade. It has a very low heat conductivity, being 1/15 that of copper.

Welding (General)

The Oxy-Acetylene process is the best for welding Monel Metal. Like other non-ferrous alloys, the welding of Monel Metal by the metallic arc process has yet to be perfected. While it can be welded by the metallic arc process it has not yet proved possible to obtain a sound weld by this method and it is not recommended where strength is required. This, however, does not apply to spot welding or to the welding of Monel Metal by the resistance method.

As an excess of oxygen or too great an excess of Acetylene are injurious to copper alloys, a neutral or slightly reducing flame should always be used in welding Monel Metal. The size of the flame depends partly on the thickness of the metal and partly on other conditions.

The welding tip should be one or two sizes larger than would be required for welding steel of the same thickness.

Avoid welding in a room where there is a draft as this tends to make the weld brittle. The air should also be excluded as much as possible by keeping the torch flame well spread over the weld.

Use only bright Monel Metal wire as a welding rod.

Except in the case of welding thin sheets, it is most important to avoid the use of any flux. Any alloy containing considerable amounts of nickel or copper will, when melted, absorb large quantities of gases if exposed to the air. These gases are dissolved in the metal when melted, but are given up upon solidification, and the result is a porous, spongy casting. Monel Metal will be found to flow with a film of oxide on its surface. This oxide helps to prevent the metal from being exposed to the direct action of the air as well as the intense heat of the flame, and for that reason should never be fluxed off. Occasionally a piece of Monel Metal may be found which is difficult to weld on account of an excessive oxide coating. In a case of this kind a little flux will overcome the difficulty, and the regular Borax Brazing flux has been found to give satisfactory results.

The weld should be completed in one place before starting in another, that is, do not weld along the whole length of the weld at the bottom or any particular place before starting to weld at a higher point. If this plan is not followed the surface at different elevations will cool off and in doing so oxidize before the weld is completed, thereby allowing the metal on being remelted to run the risk of becoming full of blow holes.

It is absolutely essential to build all Monel Metal welds well above the surface. There will be noticed at times particles of dirt or foreign matter in the weld. These should always be floated to the top by melting underneath them so that when the weld is built up any slag which might appear can be ground off, leaving sound metal underneath.

Monel Metal can be welded to almost any common metal or alloy.

The methods for welding our various products differ somewhat, and for that reason we consider it best to describe the method for each form separately.

Rods

Start with perfectly clean metal both as to the welding rod and the edges of the part being welded. Bars ⅛ in. and heavier should be beveled to approximately 90 deg. Place the bars end to end just barely touching each other. Proceed as in welding steel, preheating the ends of the bars to a red heat for a short distance away from the V before fusing. Weld from left to right on bars ⅛ in. and heavier, fusing down the sides and bottom simultaneously and allowing all foreign matter to rise to the surface. The welding rod should first be preheated before being brought into the weld and should be allowed to melt underneath the surface of the molten metal without any agitation. Avoid coming back over the weld by welding continuously from one end of the seam to the other, at the same time building up the metal on the surface of the weld as you go along. Do not concentrate the flame for any length of time on one spot so as not to burn the metal. The bottom of the V should be well fused so as to insure perfect penetration. In double V welding the second side should not be welded unless the whole piece is preheated to a dull red. Blocking is advisable in welding Monel Metal as it makes for increased speed because the welder is not afraid that the metal will get away. Most welders, however, feel that blocking is a reflection upon their skill and this method of welding of course is optional with the operator.

The weld when completed should be allowed to cool slowly. A Monel Metal weld when finished appears very rough on the surface, but this should not be taken as indicative of its soundness.

Since a weld is a casting it cannot be expected that a welded rod will be as strong as an unwelded one. A tensile strength of between 45,000 and 55,000 lbs. per square inch can be obtained in a good Monel Metal weld, which is ample for most purposes. Additional strength may be obtained by hammering the weld while still hot.

Sheets

The same care should be exercised in welding Monel Metal sheets as is necessary when welding sheet of any kind. To weld thin Monel Metal sheets up to 1/16 inch, flange the edges not much over 1/32 inch and place them butt to butt in a jig. Care should be taken that the jig is not clamped too tight, other-

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* *Courtesy of The International Nickel Co.*

† *Technical Department, International Nickel Co.*

wise the weld will crack when contraction sets in. Where a jig is not to be had a flat bar should be placed on each side of the seam so as to absorb the heat and avoid serious distortion. The edges should be tacked every 5 inches along the entire seam. Weld from right to left, holding the torch at a slant of approximately 45 degrees and moving it over and parallel with the seam with the flame directly on it. Fuse the edges of the weld flush with the sheet. Because of its thin section a sheet should be welded as rapidly as possible so as to avoid seriously burning the metal. It has been found in thin Monel Metal sheet welding that rapid welding has been retarded somewhat by the oxide coating on the metal which prevents it from running together freely. For that reason it is advisable to use a flux. The regular borax brazing flux dissolved in a little water and applied along the seam as well as on the welding wire will be found to facilitate the speed of welding and also produce a clean, smooth surface.

Another method for welding thin sheets is to place the sheets together with the edges evenly clamped and welding as above. When the weld is finished the sheets can be opened up like a book and the seam flattened by hammering.

Sheets 1/16 inch and heavier should be beveled. In order to avoid buckling, or overlapping due to contraction, the sheets when laid out for welding should be separated about 1/32 inch at the end where the welding begins and about 3/8 inch per foot at the other end. Weld from left to right much the same as rod welding, making sure to fuse the metal thoroughly to insure good union and penetration. Where the sheets are found to pull together too fast due to contraction, wedging or clamping should be resorted to, forcing the contraction to take place in the weld instead of in the sheet. If sheets after welding are found to be warped or distorted they can easily be straightened out by hammering or rolling as Monel Metal welds will be found very soft and ductile permitting of such work.

Castings

Welding of Monel Metal castings follows closely the practice of cast iron welding except that no flux is to be used. Although Monel Metal castings are less brittle than cast iron they are nevertheless subject to cracks due to differences in the rate of cooling of the different sections of a casting and this difficulty can only be eliminated by making proper allowance for expansion and contraction.

A Monel Metal casting will not permit of successful welding unless brought slowly and uniformly to a red heat. This can be effectively done with the torch flame in the case of small castings. The crack or break should be beveled and aligned in the usual way. Weld similar to cast iron and when the weld is finished it should be wrapped up in asbestos paper or some other good non-conductor of heat and allowed to cool slowly.

Large castings should be thoroughly preheated in an oven or preheating furnace and kept well covered with asbestos paper to exclude the air and hold the heat in uniform circulation around the casting. When the proper welding temperature has been reached the casting should not be removed from the furnace but welded in the fire by cutting a hole in the asbestos paper along the break just large enough to permit the torch to work without any hindrance. Use Monel Metal welding rod and proceed similar to cast iron welding. When weld is finished allow it to remain in the furnace well covered to cool slowly, thus avoiding the possibility of setting up contraction stresses.

Soldering

Monel Metal can be soldered as easily as copper. The same fluxes, solders, tools and methods are used. Zinc chloride-hydrochloric acid flux as well as most of the paste fluxes can be used with entire success.

Care should be taken when sheets or wire are to be soldered to be sure that the last annealing operation has been properly performed under thoroughly reducing conditions. If such was not the case, it is possible to have a material that will not solder due to a thin, invisible film of oxide on the surface of the material. The fact that a sheet or wire is bright is no guarantee that it will solder. If difficulty is experienced, it can be overcome by annealing the metal buried in charcoal. The same result will be obtained if the material is pickled in some corrosive agent, such as nitric acid, that will actually remove the oxidized surface. This is not recommended except in unusual instances, as nitric acid in all concentrations is very destructive to Monel Metal. Grinding will also clean the part to be soldered satisfactorily. If trouble is experienced in soldering rods or castings, the fault will probably lie in some carelessness of the operator.

Strength of Soldered Joints

Comparative tests have been made on copper and Monel Metal sheets having soldered joints. The sheets were of the same gauge and were soldered by the same man using a ½ and ½ solder. In all cases the joint was 2 inches wide with a ½-inch lap. The following results were obtained.

Material.	Actual Breaking Strength.	Broke In.
Copper	1,910	Copper
Copper	1,910	Copper
Copper	1,970	Solder
Monel	2,905	Monel
Monel	2,605	Monel
Monel	2,400	Solder

Later tests were made duplicating the above. Heavier gauge sheets were used having a 2-inch joint, ½-inch lap and using a ½ and ½.

Material.	Actual Breaking Strength.	Broke In.
Copper	6,400	Solder
Copper	6,170	Solder
Copper	6,430	Solder
Monel	7,200	Solder
Monel	6,085	Solder
Monel	7,420	Solder

Brazing

Monel Metal can be brazed in the same manner as copper is brazed, using ordinary brazing spelter with borax as a flux. It can also be "silver soldered," using a torch with the same flux.

STULZ-SICKLES COMPANY TO PUSH SALES OF SEACO SWEDISH WIRE

The Stulz-Sickles Company, of Newark, N. J., has recently become the sole distributors in the United States and Canada of the "Seaco" line of tool steel and welding wire. A complete stock of all the sizes ready for immediate shipment from the Jersey warehouse, will be carried by the concern.

Metals Coating Company of America, manufacturers and distributors of the Shoop Metal Spraying Process, by means of which metallic coatings of any kind may be sprayed on to any surface, is now in full operation at its new plant, 495-497 North Third Street, Philadelphia, having removed from their former Boston, Mass., and Woonsocket, R. I., locations.

Equipment of the Birds-Potts Co., plant of Atlanta, Ga., is of sufficient capacity to accommodate pieces to be welded weighing from 1 pound to 10 tons. Four electric welding machines, oxy-acetylene welding machines and overhead carrying cranes are part of the layout. George Bird, senior member of the company, is a pioneer in the industry. The plant represents an investment of $75,000.

Walter Petry, superintendent of welding, American Rolling Mills Company, discussed "Practical Applications of Welding in the Steel Mill" at a meeting of the Cleveland section of the Association of Iron and Steel Electrical Engineers, held on Monday evening, October 10th, at the Hotel Statler.

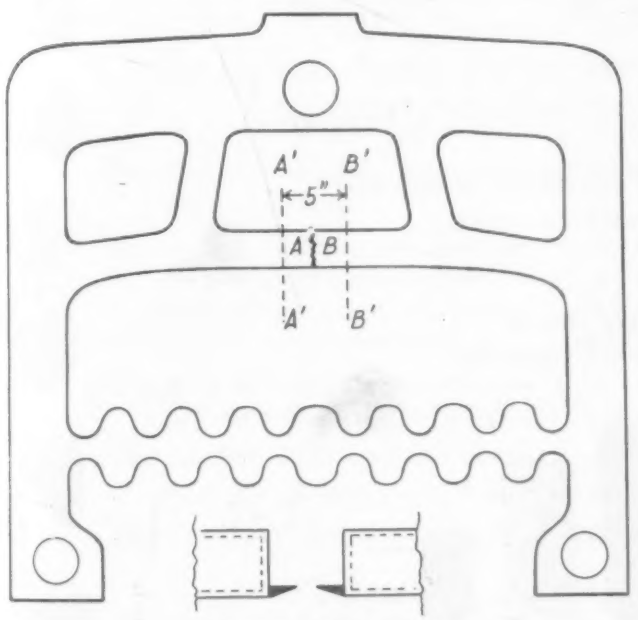
Hints for the Welder

When you finish an interesting piece of work, can you set down on paper the manner in which you went about the job, how you prepared the work and how the job was done? Have you learned some little stunt every welder ought to know? Contributions to this department are paid for. Write it down any old way – I'll polish it up. Make a rough pencil sketch and our draughtsman will fix it up fine. Line drawings are more practical than photographs. Do it today – the men on the firing line are waiting. L. B. Mackenzie, Editor.

REPAIR OF CAST IRON BOILER SECTION

By J. E. Rork

Perhaps one of the most trying repairs that a job welding shop comes in contact with is that of reparing boiler sections, and from our own experience, know that during the summer months, such repairs are left for cold days! Our usual method of welding boiler sections has been to preheat the entire section with the oil burner, or with the oil burner and charcoal. If the crack is on one side only and it is not necessary to turn the section over, the welding may be done without a great deal of discomfort to the welder, however, this is a very exceptional case. Usually, however, the crack extends so that it is necessary to weld while the heated boiler section is in a vertical position. In such cases it is very tedious for the welder, also there is danger of the boiler cracking while cooling, and a possibility that there will be a slight expansion or shrinkage so that the push nipples are out of alinement and the boiler can be assembled only with difficulty.



Welding of Boiler Section.

The above sketch shows a method which the writer used on a "hurry-up" job that recently came into the shop. We were especially anxious to do the work right the first time without delaying the work unnecessarily.

This repair was made by cutting out a piece of the section, thru A'A' and B'B', and welding on cast iron plates to the ends of A and B. On the bottom of the plates we left a boss for the purpose of retaining the fire brick so as not to injure the draft of the boiler. This method not only eliminates extensive preheating but also all possibility of the section again breaking while in use.

NEW VALVE SEATS IN CYLINDER BLOCKS

By C. H. Gerstner

Welding new valve seats in cylinder blocks is not a very common practice, I think, and the reason is, that too many times the ultimate cost of the job is greatly over estimated and the cylinder block finds itself in the scrap heap instead of the welding shop.

In the past year, I have had occasion to weld quite a few after checking up the final cost of the jobs, it was proven very profitable.

The job was handled in this manner: First the valve chambers were packed with asbestos mush up to the bottom of the valve seat. Then a round piece of carbon, the size of the hole and one-eighth inch thick is pressed down in the asbestos until the top of it is level with the bottom of the valve seat. This is done in each valve chamber. The block is then bricked on the floor and preheated with charcoal until quite rosy. It is covered with a sheet of asbestos paper and the welding then proceeded with, through a slot cut in the sheet directly over the valve holes. The slot is covered in such a manner as to expose one hole at a time. The seats are welded up solid, the piece of carbon forming a bottom for the weld. When all holes are welded, the block is left to cool over night.

All the equipment that was necessary to machine up the job was a fairly accurate drill press. A core plug is screwed into the block for centering the drill which should be the same size as the hole in the valve stem guide. After drilling through the weld a fly-cutter with a pilot long enough to enter the valve stem guide, is used to first face off the top of the weld and then bore same to proper diameter. A valve reseater finishes the job.

There should be no trouble in encountering hard spots as these are entirely unnecessary if the weld is made properly.

BRAZING CAST IRON

Editor:

In your September issue there is an article written by Mr. O. T. Hart on brazing cast iron. The uninitiated reading this would undoubtedly figure that if one man gets away with it, why not they, so the next cast iron job would be done with bronze and when it came back to the same shop or another as it would, the customer would blame the process not the operator.

I have yet to see a piece of ordinary cast iron which has been welded with bronze which will stand any real test either tensile or bending strain.

One of the many reasons why it is practically impossible to get a real job on cast iron with bronze is because in ordinary cast iron the carbon is in the form of graphite which is just the same material as the black lead in pencils and everyone knows the lubricating properties of graphite. This produces in cast iron a very greasy surface to which a brass or bronze alloy will not take.

Brass or bronze should never be used on cast iron except

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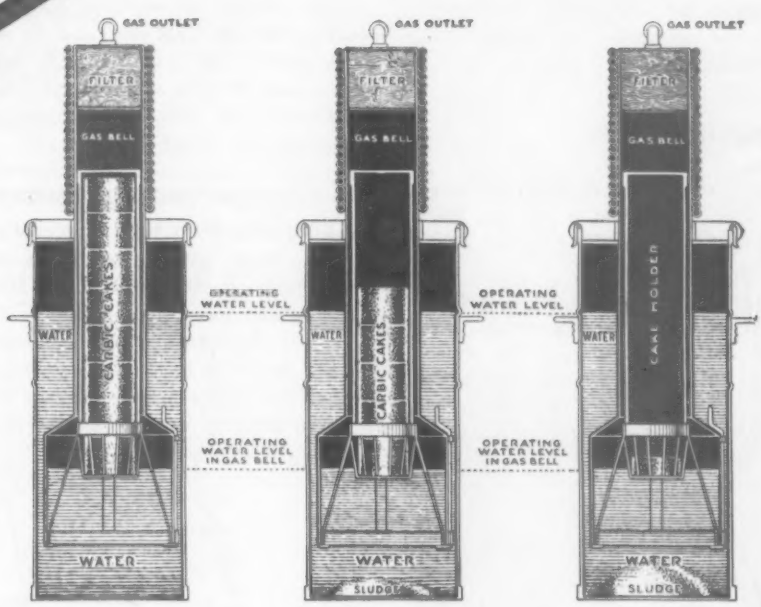

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in emergencies and then the customer should distinctly understand that it is only a temporary repair.

The ultimate goal that everyone connected with the welding game has striven for since the first has been to produce as nearly perfect a repair as possible, therefore it is only logical to assume that only the highest skilled workmanship and the best materials will do.

Alan H. Murrell

(Note:—A careful reading of Mr. Hart's article will disclose that it recommends the use of bronze for emergency work. The above letter gives some good reasons why the process is not suitable for repair work in general, and especially in cases where the piece has to stand tensile or bending strains.—Editor.)

WELDING MONEL METAL

Editor:

Taking advantage of your offer to use *The Welding Engineer* for questions, I will try and tell them about a job we have been up against, and then see if any of our aspiring master welders have any suggestions to offer.

We required a monel metal tube 8" in diameter and 10 feet 6" long ¼" material. (Monel-metal is acid proof, very tough and is rather expensive and for this reason not much known.) We tried to buy a tube all made up but were unable to do so, so we decided to buy plates, roll them up for butt welds and have our welder who is a first class man with a wide experience in welding cast iron, steel and aluminum, weld them. We got two plates, rolled them up to the required size and proceeded in the usual way to weld them together. All seams were properly V-ed out and we took great care not to have the weld cool off too quickly. We used borax for flux and employed a carbonizing flame for welding. We allowed the usual amount for expansion and contraction along the long seams. We welded the long seams first, then fitted the two parts together, and tacked and welded the whole together. Everything went nicely, the metal flowed nicely and fused well, and the job looked good, but looks sometimes deceive. When we started to test the job with 80 lbs. water pressure, we were treated to a shower bath. There were numerous small pinholes, one crack about 4" long in the long seam near the end and another in the round seam. We did not know what to make of this, as we had welded tubes like that, but made out of steel before, and never had even one leak. Well, we had to have this tube so we did the whole job over again V-ed all seams out, and used two preheating torches to keep the job hot until the whole of it was welded and then let it cool together. The second test did not show up any better. The round seam leaked very badly. We tried to weld up the various leaks without V-ing out just by running the metal together but this would not work at all. It always opened up either ahead or behind the part just welded. Finally we V-ed all the larger cracks and put heavy clamps on before and behind and so welded them.

There were not any more breaks along the straight seams then. The round seam we cut out all around and started off without tacking, but leaving an opening of about 1" opposite the starting point, for contraction, we also used a preheating torch to keep the welded part hot until completed all around. The space we left closed up before we got around and the pipe was fairly straight when completed On the 3rd test we found a number of small pinholes which we were able to caulk up.

This monel-metal is peculiar: It flows freely and fuses well, when it is heated to a dark red it is almost like cast iron and the least strain will pull it apart, but when cold the metal is soft and tough. We used borax for flux and regular monel-metal welding rods.

Now, What I would like is: Can any reader tell me where we were at fault? And which is the proper way of handling a job of this sort? This monel-metal is expensive stuff and we do not like to spoil a batch of it.

P. S.

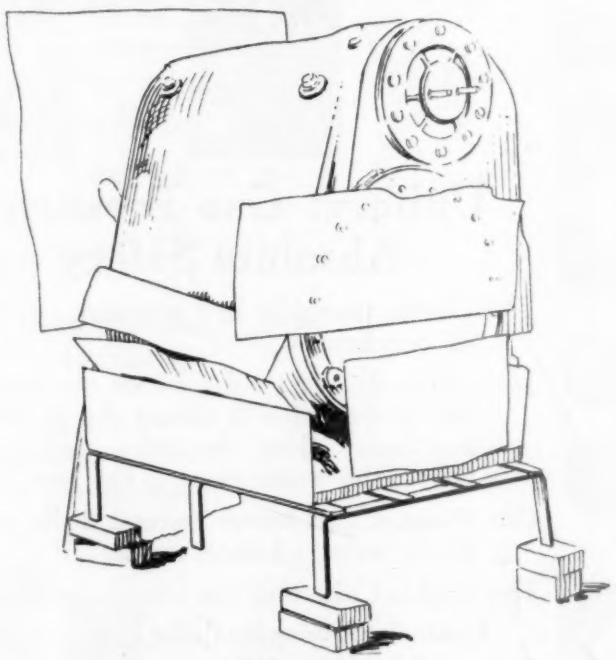
There were two things which I think helped to make the job a failure in the 1st and 2nd instance. On rolling the tube we could not roll it to the proper size, our roller being too large, so we had to force it together with clamps, and while welding, men were passing through the shop opening and closing doors, causing more or less draughts.

Theo. Sutter.

(Note:—When butt-welding monel metal sheets use a heavy monel metal rod, weld fast, and do not go over the weld twice at any point. The weld should be built up so that it is a little thicker than the rest of the sheet, and it should never be hammered until cold. Blowholes in this case were probably caused by welding too slowly.—Editor.)

PREHEATING LOCOMOTIVE CYLINDERS

In an article describing shop work on locomotive cylinders and valve parts, which appeared in the August 25, 1921, issue of the *American Machinist,* J. V. Hunter describes a method of preheating locomotive cylinders without the use of fire brick. The preparatory work consists of arranging a charcoal fire so as to bring the casting slowly to a temperature at which the welding operation can be performed without danger of subsequent damage due to shrinkage cracks when the



Cylinder Preheated.

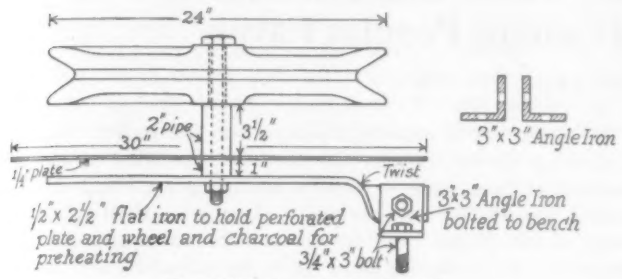
welded section cools. The asbestos lagging was only removed from the cracked section and from the bottom of the casting, so that it might more readily absorb heat at this point while the upper section of the lagging prevented radiation. All other portions of the cylinder were covered with asbestos sheets so as to retain as much heat as possible. Occasionally a charcoal fire can be built inside the cylinder, but better practice employs the fire basket that may be seen below the cylinder in the illustration. The fire basket was very simply made from a section of smoke box cinder-screen, and a light frame is used to hold it up from the floor and near to the work above.

SHEAVE WHEEL FOR CRANE BOOM

Editor:—

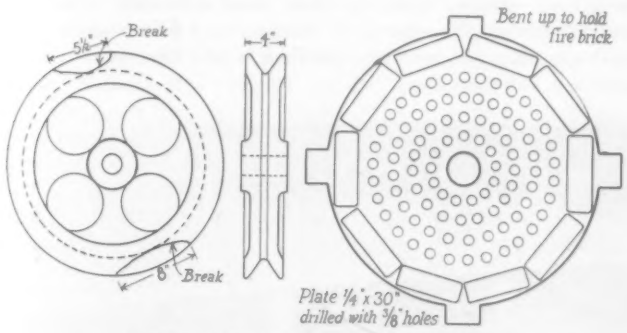
Having a sheave wheel for a crane, with the flange broken in two places on the same side, and the crane out of service,

no other being available from stock, I used the following method to weld the broken wheel: Built up a plate to act as a turntable and drilled the plate full of ⅜-inch holes leaving cleats on the sides of the plates to hold fire brick; made a



Turntable for Holding Wheel.

charcoal fire under the plate and built a furnace around the wheel, covering all with another plate. When the wheel was ready it was easy to weld one side and then turn it



Broken Wheel and Preheating Device.

around so as to get at the other side quickly. The crane was in service in three and one-half hours. This turntable device has since proven very useful on similar jobs, and may be of service to some other welder.

F. C. Drake.

CLEANING RADIATORS

Editor:—

Please give us some information on cleaning radiators. A radiator gets very greasy and dirty and if we had vats of acid to dip them in it would make soldering very easy.

J. W. Gillispie.

Answer:

Mix one quart of muriatic acid with five quarts of water, and one quart of lye with five guarts of water, then mix the two solutions. This makes a good cleaning solution.

NEW FRENCH DEVICE FOR HANDLING CYLINDERS

In a recent number of the Revue de la Soudure Autogene is published a description of a new French device for transporting gas cylinders. This device is called a "Cylinder

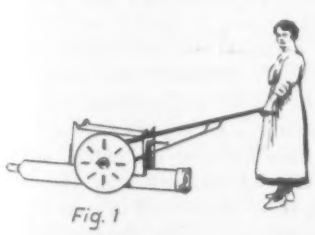


Fig. 1

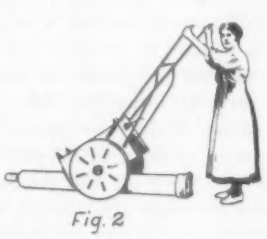


Fig. 2

Wheelbarrow", and is composed of a metallic body mounted on wheels, inside of which are placed two pairs of automatic claws for holding the cylinder, carrying it about, and placing it, by simply manipulating the arms of the buggy. The illustrations make it easy to understand the operation, which is as follows: starting with the cylinder lying on the floor the device is wheeled over the center of it; when the arms are raised the forward claws automatically grasp the cylinder;

Fig. 3 Fig. 4

when the arms are lowered the rear claws take their hold; now raising the arms to the normal position the cylinder is held clear of the floor by the claws, and ready for transportation. To release the cylinder it is necessary only to give a quarter turn to a crank which causes the claws to open, allowing the cylinder to slide easily to the floor.

WELDED HEAVY DUTY TANK

In the accompanying photograph is shown a large pickling tank recently welded for the American Rolling Mill Company by the Electric Welding Service Company of Pittsburgh.

Welding Displaced Rivetting Here.

This tank is to be used under very severe conditions for pickling steel. Although the specifications originally called for riveted construction it was decided to try welding, and not a bolt or rivet was used in its construction. The dimensions are 21'x9'x8'. It is constructed of quarter-inch plate and 5x5x5/16 angle iron.

TORCH SAVES EXPENSIVE DIE

A Chicago manufacturer suddenly found his production stopped by the cracking of a cast iron die which was used for moulding an essential part of his product. His method of using the mold had been to pour molten babbitt metal into and then tap the edge on a stone to loosen the small casting. The die, or mold, cracked across the point where the pattern had been machined out, and the whole affair was rendered useless. Figuring the cost of a new die at $125.00, the manufacturer decides to see whether the old one could be reclaimed at a smaller figure. The job was turnd over to A. J. Derenzo, foreman welder in the shop of the Chicago Welded Products Company, Chicago. Reclaiming the broken piece proved to be a simple matter. The die was first heated and straightened, then the crack melted out with the torch. A high grade cast iron welding rod was used to fill up the V, and the die was slightly reinforced on the back. It was not necessary to re-machine the pattern because the original crack did not extend clear through and the welding operation had been done so delicately that the pattern was not disturbed. The entire job took only a few minutes and the amount of materials used was almost negligible.

A Survey of Oxy-Acetylene Welding*

The Process Is Only a Few Years Old But Has Made Great Strides Forward Gaining Popular Favor

By Lorn Cambell, Jr.†

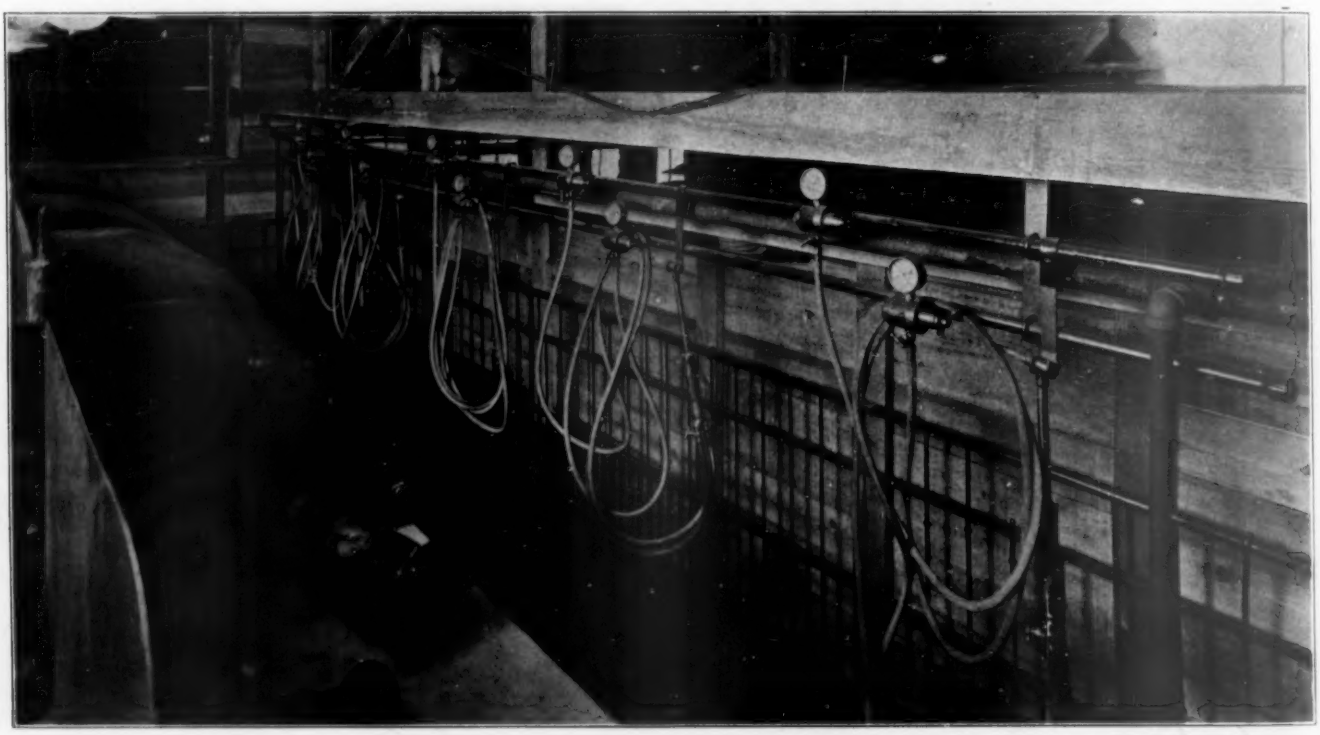
AS we look about in the manufacturing industries of today it is plain to see that the welding processes are being rapidly recognized and introduced in many new phases. Our office equipmet is now rendered fireproof and constructed to last a lifetime, thanks to the art of welding. Our window sash and doors follow a similar construction. Cooking utensils of various metals have spouts and handles welded on. The automobile industry, manufacturers of airplanes and even building contractors are looking to the process of welding to produce a stronger and more efficient bonding method.

Turning our attention to the field of oxy-acetylene welding we find, that while there was some slowing up in the sales and manufacture of apparatus for a period last year, that in comparison with most industries the let-up was very light and today many manufacturers are behind with orders. The reason for the continued demand for welding equipment may be attributed to the important role it plays in repairing and salvaging, as well as in manufacturing. With the general decline in prices the purchase of new parts was largely abandoned and many old parts were repaired.

Many distributors of automobile tractor or implement parts who previously decried the process of welding, were perfectly willing to accept it when they were confronted with the choice of tying up large sums of cash in replacement parts, which incidentally were dropping in price daily, or having their customer's parts welded. In the latter case, prompt service was rendered and in most cases a considerable saving effected.

The engineers of many companies were inclined to welcome a slacking up in activities in the manufacturing world. It meant that they were to have a breathing spell and a much needed opportunity to overhaul and tune up their machines, many of which had been in almost continuous operation for five years. In so doing, many parts were found either broken or worn to such a degree that a replacement would be necessary were it not for the welder.

Salvage corps, taking advantage of the recess, proceeded to "clean house." In reducing the scrap pile to a mere nothing by removing broken drills and taps from castings; correcting machinists' errors; filling up blow-holes and other defects uncovered during the course of machining, and restoring missing lugs, etc., was another instance where the welding torch proved a valuable asset.



Welding Laboratory. Work Tables at the University of Minnesota. In the Line Behind Each Torch, a Separate Pair of Regulators and Gauges Permits the Students to Obtain Any Desirable Gas Pressure.

With the oxy-acetylene welding process only a few years old and its playing such an important role in this present readjustment period, it may not be out of order to consider it a benefit to mankind and an essential of inestimable value. What has the future in store for it? Evidently our educators deem it an important future factor in the engineering field, for in most of the institutions of higher learning throughout this country courses of instructions have been, or are being, drawn up for teaching the fundamentals of welding. In this city even the high schools are doing their share and in every case where any of the mechanical arts are taught, instruction in oxy-acetylene welding is now being given. The accompanying views illustrate the manner in which the apparatus is arranged in one of our largest western universities. Attention is invited to the manner in which the gases are supplied to each student. The oxygen and acetylene gases are piped in sep-

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**Paper read before the Society of Automotive Engineers, Minneapolis,* April 6, 1921.

†*Engineer, U. S. Welding Co.*

arate lines at the rear of each set of work tables. Each line carried a medium pressure of gas which is controlled by master regulators, or reducing valves, at a manifold where the tanks are connected. In the line, behind each torch, a separate pair of regulators and gauges permits the student to obtain any desirable gas pressures. The gentleman shown manipulating the torch is the professor in charge of welding.

The speaker, during a recent visit in the east, found that at Philadelphia and many other large centers, manufacturers, too, are becoming very enthusiastic and are organizing and conducting welding schools at their own expense.

Our leading economists inform us that the most successful manufacturing enterprises from now on will be the ones operating along the most efficient lines. The wideawake engineer will therefore give due consideration to the process of welding. Manufacturers of steel products such as the various types of barrels, tanks and pressure vessels should give considerable attention to design in order to produce the strongest and most efficient product at a low cost. Rivets are being fastly replaced by the weld. There are three good reasons why this should be done. First, a better product can be produced which will stand more abuse, having a permanent seam which will not leak. Second, the cost is greatly reduced. Third, repairs if necessary can be readily made. If a seam breaks along the line of rivets, it is a very difficult proposition to make a repair under ordinary conditions, whereas if a crack is found in a welded vessel, the same can be welded in very short order. There are many other reasons why tank manufacturers should use the welding torch in preference to the rivets, one of the most important being the fact that fittings of almost any nature can be attached in any position with ease, allowing a much greater latitude in design and structure. Steel castings may be fused to cold rolled shafts or other stocks, thereby opening up another lane. Automobile or tractor frames, and structural iron of all kinds, need know no limit as to design, for various parts can be fused together at any angle desired.

Has the oxy-acetylene welding process reached its height? Emphatically no! While the present applications seem unlimited there remain many problems, which, when solved, will tend to broaden the field. Cast iron and aluminum are metals which are quite easily fused. In some instances the former may come out with a few hard spots or blow-holes, but these can nearly always be traced to lack of heat. With aluminum the conductivity of heat and its expansion and contraction are things which may require a little study. Malleable iron presents a problem all its own; being annealed, how can part of it be melted and again restored to an annealed state? At the present time, a tough bronze is used to mend malleable iron; by so doing the annealing is not destroyed and a union results which is usually amply strong, providing a slight reinforcement is possible. Brass presents no difficulties if the correct filler-rod and flame are employed. This applies to copper and steel when they are cast, but when drawn or rolled the heat causes the molecules to expand and changes the nature of the metal surrounding the weld. A practical method of restoring this metal to its original condition should warrant consideration.

If calling particular attention to certain "Do's and Dont's" pertaining to the welding of special metals will result in the making of better and sounder welds then it may not be amiss to dwell a moment upon the welding of mild steel.

Steel may be a very commonly used metal and one of the first to be welded, but the fact remains that it is the most difficult of all metals to successfully fuse. Many welders are of the opinion that steel is steel and that if one kind of steel gives certain results under the influence of the welding flame that all steel will act in a like manner, but such is not the case.

To simplify matters let us separate our principal factors into different classifications. First comes the "Human Element," next "Apparatus" and then "Filler Rods." The importance of each is shown by the order given. More will depend upon the "Human Element" than anything else, for the welding plant will not do the welding any more than a blacksmith's forge will produce chains, chisels, tongs or any other item by itself; it is the "know-how" of the operator that really produces results. Any of us might go out and purchase a doctor's equipment but this act would not make us doctors. Much schooling and experience is necessary, and so it is with the welder, whom we might term a metal doctor.

In welding mild tank steel there is much for the operator to take into consideration; the carbon content of the metal, the surface oxide or mill scale, the size of the welding tip, adjustment of the flame and size of filler rod all have a direct influence upon the weld. The carbon content varies from .15% to .25% in steel of this nature and a tensile strength of 52,000 to 60,000 is usually required. As the amount of carbon is increased naturally the welding is rendered more difficult. We would suppose that were two welds made on a given material using the same filler rods and apparatus, but different operators that approximately the same results could be expected, but the "Human Element" varies to such an extent that this is not the case.

Protection Afforded Each Student of Welding at the University of Minnesota, by the Shields Which Divide the Work Tables Into Different Compartments.

Steel in a molten state is very susceptible to changes; therefore, it should be held in that condition no longer than is absolutely necessary. Nitrogen and oxygen from the air will be absorbed by the melted metal. This reaction is greatly increased when the metal is overheated by using too large a tip. This fault is usually found where an effort is being made to "speed up." As the metal cools and contracts there is a natural tendency on the part of these gases to free themselves and small blow-holes or pin-holes will make their appearance. This metal will have a tendency to be hard and brittle. If rewelding should be found necessary, the metal will again be exposed to the same treatment and, of course, an added weakness is to be expected. The correct sized tip will all depend upon the operator, for very few men will obtain the same results even if all material and equipment are the same. Here are two welders, each having worked on test pieces cut from the same plate; the same torch and tip were used, gases from the same containers and the same grade of filler rods, yet we find in testing that one specimen has about 50 per cent more ductility in the vicinity of the weld than the other. This is rather surprising in a way, but it only confirms the importance of the "Human Element" mentioned. In accounting for this difference we examined the broken

welds and found that the welds themselves had a flaky grain with all the characteristics of a casting, only not quite as uniform, while the pieces which were welded were of rolled stock with a very fine close grain. There existed an intermediate space adjacent to the welds where the intense heat had caused the molecules of the original stock to separate and the grain appeared much coarser. It is plain to see, therefore, that a weld is a casting at best and that the longer the metal is held in a heated condition the greater will be this intermediate section (up to certain limits) and the more ductile, so we can assume that one of these welds required a longer time to execute than the other. It is not desirable under ordinary conditions to use a larger tip than necessary because of the reasons given heretofore, but when a steel weld is made too rapidly, in addition to the likelihood of not having thorough penetration the grain limits will be very marked and narrow, indicating a weld with little ductility and one which is very likely to crack alongside of the weld after being placed in use. To obtain the best results these factors should be pointed out to the welders and each should then choose the size tip which could be manipulated to the best advantage.

In welding most metals it seems sufficient to have what is termed a "neutral" flame, but in steel welding a much finer limit must be drawn. The cause of faulty steel welds is due to a very large extent to the wrong kind of a "neutral" flame. There are "neutral" flames and "neutral" flames, some soft, but for the most part they are very harsh. With the latter flame it is next to impossible to make a thoroughly satisfactory steel weld. While a harsh flame may be all right for building up worn spots and the like, it has no place in the lighter sheet metals. If used in this class of work, not only will there be a tendency to blow the molten metal away from the weld, but an overheating is very certain to take place, which is indicated by excessive sparks being given off. It is absolutely necessary that a soft "neutral" flame shall be used when making any kind of a steel weld and it might be added, that the softer the flame the easier it will be to effect a perfect fusion. A soft flame will not blow the metal, neither will it overheat and cause sparking. With a low carbon steel there should be hardly any sparks appear while a weld is being made, and this is a very good method of determining whether an operator really knows his business. If sparks are in evidence, one of two things is taking place: either there are impurities in the piece being welded or the metal is being burned.

In steel welding the apparatus plays quite an important part. While there are many different makes of apparatus on the market today and all seem to function fairly well on most metals, yet there are few indeed that will give the adjustment required for steel welding. There should be a regulator on each line, i. e., one to control the acetylene gas and the other the oxygen gas. These regulators must be so constructed as to maintain an unvarying pressure so that there will be no change in the welding flame while it is operating. The welding torch should be designed to give a slow, uniform delivery at the tip of the gases which have been thoroughly mixed. This will permit complete combustion of the gases, no unburnt gases can then enter the weld, and the preheating flame which envelops the neutral flame will exclude the air and protect the weld so that it will be possible to carry a small clear pool of melted steel along the seam. With the aforementioned equipment, the desired results can be obtained and greater efficiency will follow.

In choosing filler rods, freedom from impurities and a low carbon content are the main consideration: The size has a direct relation to the size of the flame. If the rod is too small, it will usually burn, whereas if too large, it will not fuse with the metal being welded and will probably have a tendency to stick. When introducing the filler rod the flame should come in direct contact with the rod as little as possible. It is desirable to melt the end of the filler rod in the molten metal rather than by the flame as there is less chance of changing its character.

When making ripple welds on pressure vessels it is necessary for the operator to hold his tip at the correct angle and have his flame adjusted so a small pool of clean melted metal may be carried along his seam; constant watching is required to see that each side of the weld is thoroughly fused; penetration must be complete, and the filler rod added to give a slight reinforcement so that the resulting weld will measure about three times as wide as the metal is thick.

In concluding let us again focus our attention on the "Human Element" in order to see what steps can be taken to insure the greatest efficiency from this source. By testing welds periodically and publishing the results an "Esprit de Corps" may be built up among the welders in a large shop which will encourage all concerned and will certainly assist in producing better results. In testing welds it is necessary to break the weld so that the interior may be inspected for penetration, adhesion, and oxidation for a weld must be more than skin deep and the nature of the interior can seldom be

WELDING PROMOTION COMPANY

There has been formed recently in New York The Welding Promotion Co. which will operate as a co-operative company through which job welders can secure assistance in improving and expanding their business. The new company aims, first of all, to assist the welder to become a better business man, and secondly, to prepare and furnish the welder with practical, right advertising by which a better public understanding of what welding is and can do will be created. The new organization aims to follow the lead established in many other lines of business in which co-operative advertising has been a tremendous success through giving expert advertising service to the individual who could not otherwise provide it for himself because he lacks time, experience or money.

WELDABILITY OF LOW CARBON STEEL

While the oxy-autogenous welding process is steadily extending its scope, experience has shown that by no means are all grades of iron and steel suited for it. Writing in a German contemporary, C. Diegel states that certain impurities are having rather deteriorating effects. This refers especially to sulphur and silicon, the percentages of which should be kept as low as possible while carbon should also be below 0.3 per cent. Manganese the author considers to be an advantage; a high percentage of this element is even held to compensate the harmful effects of sulphur and silicon but the raising beyond a certain mark offsets all the initial advantages owing to the fact that sheets having a high percentage are difficult to work. Phosphorus, a low content of finely distributed aluminum (originating from the reduction) as well as chromium and tungsten originating from scrap, were found to have virtually no influence at all.

The foregoing shows that the material of the pieces to be welded determines the efficiency of the joint, but experiments have proved that the raw material of the wire used for welding plays an even more important role. In this connection it is interesting to note that the chemical composition of the wire is by no means always determining the quality of the joint, so that for the time being there appears to be no absolutely reliable criterion in this respect. In view of this fact the writer recommends trial weldings with subsequent testing of the joint, preferably by the bending test. It would appear that the slag contained in puddled iron has a rather beneficial influence; the wire must furthermore be free from impurities, especially sulphur. Charcoal puddled iron and electric iron are considered the best suited materials for wire. —*Iron Age.*

PROCEEDINGS *of the* AMERICAN WELDING SOCIETY

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THE POSSIBILITIES OF FUSION WELDING*

By A. S. Kinsey†

THE possibilities of the welding of metals by fusion are far greater than had been expected. It seems but a short time ago that practically only the railroad shop superintendent and his welders were capable of appreciating the value of the fusion weld. The process seems to have drifted into existence without a sponsor, and for a number of years it failed to receive the attention of the man who should have been most seriously concerned—the mechanical engineer. Of course it is easy now for us to appreciate the value of this method of making a weld, and we may wonder at the indifference of the technical men regarding its merits.

There never was any doubt in the mind of some men as to the possibilities of the fusion weld, and now the most encouraging signs are found in the interest displayed by the technical engineer and his ready approval of the process.

Important metallurgical principles are introduced when a piece of metal is melted for welding, and no one can appreciate this more than the engineer. He finds in the process not only a fine tool for repairs but he already has learned to apply fusion welding to the manufacture of metal parts and in construction work. No modern mechanical process possesses more encouraging possibilities than the welding of metals by fusion. There are good reasons for this. Let us consider some of them.

An ideal condition would be to have all members of a structure solid and without a made joint. The best piece of metal is the one of continuous grain, unriveted, unwelded, so that while a joint is a substitute it is well known that in many instances certain mechanical designs and repairs require either soldered, riveted or welded joints. For strength the choice must be the riveted or welded joint. The riveted joint has its points of advantage and in many cases it can not be superseded, but it will not serve where uniform thickness of the metal of the joint is required, nor is it always to be depended on for tightness where there is breathing action and high pressure.

The welded joint is not of modern conception, the forge weld undoubtedly dates back to the earliest working of metals. However, the other kinds of welds have been in use less than 20 years. All welding is done by either one of two principles, plasticity or fusion. The forge, the electric resistance and the thermit compression welds depend upon plasticity, while the electric arc, the thermit cast and the oxyacetylene welds employ the principle of fusion. The respective merits of these two methods of making welds are rapidly becoming well understood.

Welding by plasticity has accomplished much. We have but to consider the manufacture of ordinary wrought iron and steel pipe to appreciate the value of the forge plastic weld. The speed and non-oxidizing features of the electric resistance weld also have proved to the greatest advantage, as in the making of steel chain for example.

But the plastic weld is limited in its application and is confined almost entirely to mild steel. The fusion weld however has a broader range of usefulness among the metals. Especially in this true of the oxyacetylene weld which is applicable to mild steel, tool steel, high speed steel, the new alloy steels, cast iron, wrought iron, aluminum, copper, brass, bronze, lead, tin, zinc, in fact all of the commercial metals may be welded by the oxyacetylene torch.

Now the possibilities of a good fusion weld depend on (1) high tensile strength, (2) ductility, (3) density, (4) control of the welders, (5) a proper method of testing welds.

TENSILE STRENGTH. The tensile efficiency of a weld is based on its thickness being the same as that of the base metal. This efficiency is of first importance but it must not be obtained at the expense of ductility, that is the bending and stretching qualities of the metal. In the welding of steel, for example. the ductility is of much importance. Again to secure the proper tensile efficiency the welded metal must be thoroughly fused to the sides of the vee of the base metal. One of the best ways of securing a high tensile efficiency, say in mild steel, is to use a welding rod of nickel steel having a tensile strength nearly double that of the base metal. The result is likely to be a weld of higher tensile strength than its base metal. Of course the simple reinforcing of a weld is common practice.

DUCTILITY. The ductility of a fusion weld, particularly of steel, must be considered, although there now are some who would argue that a weld does not need to have bending qualities. One of the best illustrations of the value of ducility in a steel weld is to be found in the manufacture of welded steel tubing, which can be made cheaper than seamless drawn tubing. In order to obtain small size tubing the practice is to weld the steel in diameters of from 1 to 2 inch and then cold draw these tubes to the smaller sizes desired, some of them being as low as $\frac{5}{8}$ inch outside diameter with a $\frac{1}{8}$ inch hole. It is to be noted that this tubing has an oxyacetylene fusion weld along its full length of many feet which must be capable of withstanding the strain of repeated cold drawing as the large tube is reduced to the smallest diameter. The weld not only withstands this treatment but also is found to be ductile enough to successfully stand being flattened, crushed, knurled or bended. The welding of the larger size tube is done at the rate of from 3 to 5 ft. per minute with multiple tips in an automatic machine.

**Address delivered before the Cleveland Section of the American Welding Society, at a meeting held May 6, 1921.*

† Professor of Engineering Practice, Stevens Institute of Technology.

POROSITY. One trouble with welds has been the lack of homogeneity of the welded metal, and usually the trouble is due to oxides. This applies to all methods of welding but probably less trouble is experienced with the oxyacetylene weld. In most cases the weld must be absolutely nonporous and the density of its metal should be equal to that of the base metal. A fine illustration of what may be accomplished in this direction may be found in some recent designs of electric sterilizing transformers. In this type of transformer a high voltage terminal is filled with a combination of helium and nitrogen gases held at a constant pressure of about 150 lb. to serve as a gaseous dielectric. Of course it is necessary for the pressure of the gas to be maintained constant and therefore the welded joints of the transformers must not allow the gas to leak away. Many attempts were made to weld these transformers but the welds proved to be so porous that the gas pressure could not be maintained until the oxyacetylene process was brought into use. This has proved highly satisfactory and the elimination of oxides has been so complete that the weld is absolutely nonporous so far as the use of gas at high pressures is concerned. Other evidences of the nonporosity of the fusion weld may be found in its use in refrigerating systems where anhydrous ammonia plays an important part. In this case the weld must withstand high pungent gas pressures and be absolutely tight. The oxyacetylene weld has been very successful in this regard.

CONTROL OF WELDERS. There must be a better control of welders. We must know more exactly what these men are doing in all of their work. Much attention is being given to this problem at the present time by the American Welding Society. One plan discussed is to require the shop foreman employing welders to have a thorough knowledge of the possibilities of the art so that he may be capable of inspecting the work of the welders from time to time just as he is familiar with and can pass on the work of other mechanics in his shop. The welders themselves should be trained to thoroughly understand the principles of their work by giving them say an evening course in the practical metallurgy of the subject. With these precautions, and assuming the men to be of average intelligence and dependability the danger of poor welds should be greatly diminished. Many oxyacetylene welding schools are springing up over the country and they will undoubtedly accomplish much good in this direction. There is another plan for controlling welders which is being considered carefully and undoubtedly will meet with much success. We speak of the testing of welds.

TESTING OF WELDS. A number of ideas have been suggested for the testing of welds. Some shops require their welders to make sample welds each month which are tested and the results posted on a blackboard for all the shop men to read. This has both its advantages and disadvantages. Another plan is to cut out a section of a weld, where it is practicable, and examine it for fusion and porosity. If the welder does not know just when his work is to be tested, he is likely to be forced to constant care. We know of some cases where welders are being required, after making a good sized weld, to stamp their initials and the date alongside of the job so that there can be no question as to responsibility for workmanship, if the weld fails. The testing of welds is of vital importance and it will be of interest to many to learn that a special committee of the American Welding Society is devoting considerable attention to the question at the present time.

In the above remarks we have briefly indicated the factors that usually determine the possibilities of fusion welding. Alongside of these may be placed the experience of thousands of repair and manufacturing plants of this country where the application of fusion welding is meeting with almost uninterrupted success and satisfaction. The fusion weld made its debut in the repair shop. It has proved itself of inestimable value in that place. During the past 5 years however it has been gradually expanding to the manufacturing plant where now it is of the greatest value. Its application to the automobile industry is well known. There was a time when most all steel tanks were rivetted. Now there are millions of them being made each year with all welded joints. The all-rivetted locomotive fire box is now being welded. Intricate castings which formerly it was impossible to make are now cast in part and welded. One of the newest and most interesting applications of the oxyacetylene process is in the welding of telegraph and telephone wires. Some of the railroads have started this practice with the idea of eliminating the ordinary twisted splice joint. The results show that the mechanical strength of the joint is often greater than the wire itself and

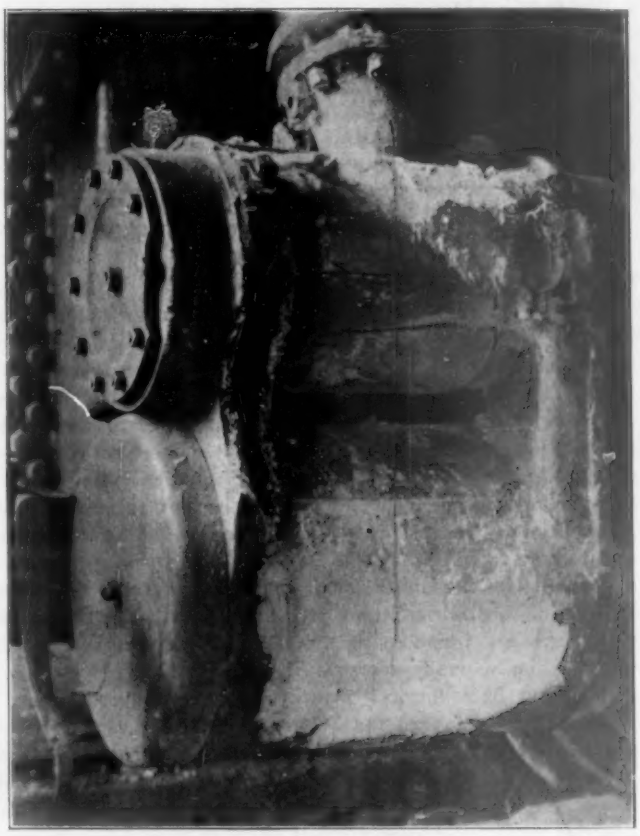

Fig. 1. Broken Cylinder.

that the conductivity efficiency in some instances is as high as 100 per cent better than the twisted joint. The first cost of the work may be higher than the twisted joint but the increased conductivity and the fact the joint will never have to be made again makes the welding highly preferable.

We might cite many illustrations of the possibilities of fusion welding in manufacturing, but probably what will be of greater interest to you will be to tell you of the success of the oxyacetylene fusion weld in the new alloyed steels. Fine success has been obtained in the experimental welding of steels such as nickel, chromium, tungsten, cobalt and vanadium. The depositing of alloyed steel on cheaper base metals where intense heat and wear are concerned has been successfully accomplished by the oxyacetylene torch. This is opening up a fine new field for fusion welding and making available certain applications of alloyed steels which were not practicable before.

Just as it is not difficult to produce convincing evidence of the value of fusion welding in modern shop practice, so it may not be considered too venturesome to prophesy the future possibilities of the fusion weld. A process which started as a makeshift of mechanics has become a sure right hand method of the technical engineer for the repair and production of machinery whose value is incalculable.

WELDING OF LOCOMOTIVE CYLINDERS WITH TOBIN BRONZE*

Joseph T. Paight†

How Tobin Bronze has been used in the repair of locomotive cylinders is illustrated by this series of three photographs.

The first shows an engine as it was received at the shop after it had been in accident with another engine and had a piece broken out of the cylinder. The first thing we did to this cylinder to get it ready for welding was to take off the two front piston heads and take out the piston and make two blank heads

Fig. 2. Repair Half Completed.

out of iron that would fit inside of the studs of the cylinder head. Then we plugged up the exhaust nozzle and V-d out the pieces that were broken out to a 45° V, and drilled in on the inside of the "V" for ½-in. tap bolts and tapped them out and screwed the tap bolts in until we had ¼-in. from the under side of the head to the casting, just so as the bronze could get under it well. At the outside of the "V" we took a chip off ⅛-in. thick, back 1¼-in. from the "V" all the way around the break. This is done so you will have no trouble in tinning the casting and then we welded the pieces that were broken out together and set it up in place and left it out ⅛-in., tacking it well in four places. We then put in an oil torch in the big cylinder burning slowly for about ten minutes and then took it out and put it in the top cylinder for about the same time—we then took the oil torch out and put on our blank heads and put our oil torch in through the back head of the big cylinder, letting it burn slowly. In about one hour's time the cylinder was hot, that is, just so you could not hold your hand on it, we then cut the oil torch down as low as we could and started one man welding across the bottom. When we got across the bottom we started another man in and they both came up the side together.

Figure 2 shows job partly welded, also of the studs. When they nearly reached the top only one man could work. He finished the job and we covered up the place where we were welding with asbestos. We then shut off the oil burning torch and plugged up the hole in the back head where we had the torch. We put 75 lbs. of Tobin Bronze in this job and the time for welding it was eight hours. In the morning this cylinder was cool and then we started to put it together again and get it back in service. Figure 3 shows the finished job. In using this Tobin bronze on cast iron you just heat up a little place about ½ inch and put a thin coating of bronze over it or, in

Fig. 3. Cylinder Ready for Service.

other words, just tin your casting and then start welding, always keeping your casting tinned ahead of your weld from 1 to 1½ inch. You can always be sure that you will have a good weld if you do this.

The time we saved by welding the cylinder with Tobin Bronze was as follows:

Three days to build an oven and tear it down.
One-half day to heat it.
One day for it to cool.
Two days to rebore bushings.
One day longer to weld it with cast-iron.

We have cylinders that have been welded with Tobin Bronze out in service for seven months and have given us no trouble at all.

Plans have been filed by the Air Reduction Co., New York for the erection of the first unit of its new plant at 1106-16 Ridge Avenue, North Side, Pittsburgh, for the manufacture of commercial oxygen. Estimated cost about $60,000.

Metal specialties, solders, fluxes, etc., will be manufactured by the newly incorporated Aluminum Flux Co., Rhinelander, Wis. The company is capitalized at $15,000.

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*Extract from a paper read before the American Welding Society, Metropolitan Section, May 17, 1921.

†Welding Inspector, N. Y. N. H. & H. R. R.

Rock Weld Asbestos Paper

This label guarantees you a prepared asbestos rock welding paper made especially to insulate you from the heat rays—gases and fumes while engaged in welding. "It insures a better job because it is a cooler one when using **"Rock Weld."** **A Free Sample** sent on request is the best way to convince you that the **"Servicised"** Label guarantees a piece of goods made for the purpose. **Buy by this Standard.** All rolls bear the mark **(Rock Weld)** and the label **(Servicised).** 50 and 100-ib. rolls.

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Counted 8 words to line. Add 6 words for keyed address.

For Sale—A Lincoln gasoline driven electric welding outfit very little used, connected with an Ingersoll-Rand compressor and mounted on a 5-ton truck enclosed in a van body with all necessary equipment, including 1,000 feet of hose and cable; suitable for all kinds of electric repairs. Will sell cheap and give demonstration by appointment. Bournonville Welding Co., Inc., 241 West 64th Street, New York.

For Sale—A well established welding shop. G. A. Raguse, 110 N. Madison Street, Rockford, Illinois.

Position Wanted—Experienced welder wishes position as salesman and demonstrator for a reliable welding equipment and material company. Address 5, care The Welding Engineer.

Position Wanted—Experienced gas and electric welder with 6 years of practice with all kinds of metal wishes position as salesman and demonstrator for a reliable equipment concern. Willing to go to South America. Would take work as welder also. Address 6, care The Welding Engineer.

Wanted—Capacle practical welder who has had considerable experience with different metals and who also has some background mechanical experience as demonstrator and salesman for reliable concern. Address 7, care The Welding Engineer.

For Sale—Two low pressure Oxweld Acetylene generators; 100 pounds carbide capacity. General Boilers Co., Waukegan, Ill.

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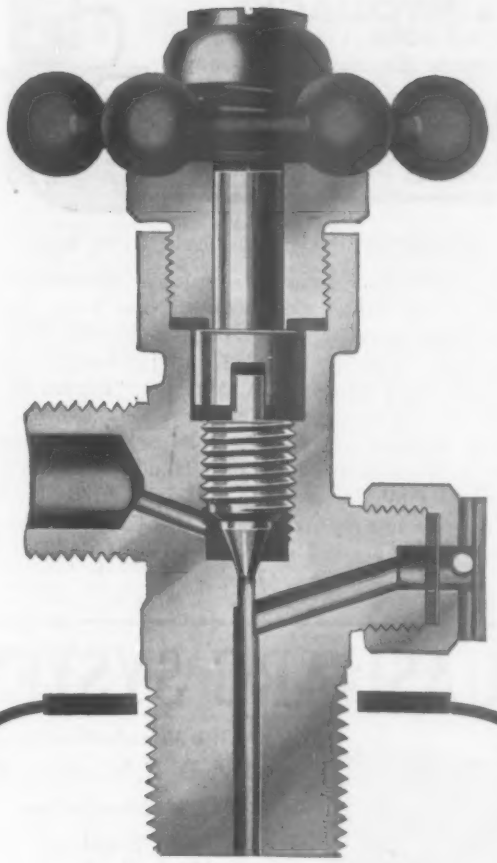

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CURRENT WELDING LITERATURE

TUBE WELDING MACHINERY AND FABRICATING EQUIPMENT—Booklet published by Davis-Bournonville Co., Jersey City, N. J. Lists machinery for producing welded tubing from commercial steel sheets, or rolled strip stock, and briefly describing the procedure. Gang slitters, tube forming machines, welding machines, straighteners, seam grinders, cutting off machines, drawbenches, swagers and bending machines are shown.

ACETYLENE AND WELDING IN THE FAR WEST—A former president of the British Acetylene and Welding Association, now residing in Seattle, Washington, comments freely on the welding industry as he find it in the United States.—Acetylene and Welding Journal, London, September.

WELDING A MOTOR CYCLE CRANK CASE, by David Baxter—Details of welding an aluminum casting by a combination of the flux and puddle system.—American Blacksmith, August.

GAUGES AND REGULATORS, by David Baxter—A lesson to beginners on the use and care of gauges, regulators and hose.—Acetylene Journal, October.

THREE TYPES OF ALLOY SHEET STEEL, by Horace C. Knerr—Effect of electric and acetylene welding on chome vanadium, nickel-chromium, and 3.5% nickel steel. Tests were made to determine the comparative value of the three alloys. All the steels were found more difficult to machine than low carbon steel sheet, but could be sheared, milled, drilled, etc., with ordinary tools in the annealed state with reasonable facility. Tests made at another time on steels of similar analysis, heat treated for 125,000 to 150,000 lb. per sq. in. showed that they could be drilled and machined on milling cutter or lathe with ordinary drills or high-speed cutters, although with some difficulty. Impact and fatigue tests, at least of a comparative nature, on these three steels would be interesting and valuable, but lack of time has prevented including them in this investigation. As the other two types of steel failed to meet the bend test and would therefore not be suitable for the fabrication of fittings of the type intended, and as chromium-vanadium steel showed excellent qualities in bending, and was also satisfactory under all the other tests applied, this steel was adopted.—Iron Age, September 22nd.

WELDING A TRACTOR CYLINDER CASTING, by David Baxter—How a crack in a rather inaccessible part of a cylinder casting was welded. The crack was surrounded by metal walls of varying thicknesses so preheating was necessary.—American Blacksmith Auto and Tractor Shop, September.

WELDING IN AUTOMOBILE SERVICE WORK, by J. D. Diehl—Owner of high class car need no longer travel on beaten paths of motor car for fear that something might break and car might be held up for a week or more while waiting for part to come. This is due to increasing use of welding outfits by smaller garages. One of a series on welding in automotive field. Automobile Trade Journal, September.

INTERESTING PROGRAM OF I. A. A.

At the convention of the International Acetylene Association, held at the Hotel Commodore, New York, October 4 to 6, the following papers were presented: "Welding Rods", J. R. Dawson; "Pipe Welding", H. B. Iglehart; "The Manufacture of Welding Wire", C. A. McCune; "Bronze Welding", H. I. Walsh; "Future Job Welding Shops", G. O. Carter; "Acetylene House Lighting", J. I. Banash; "Acetylene from the Point of View of the Insurance Man", Dr. A. D. Risteen; "Machines for Welding and Cutting", Fred E. Rogers; "Safety Aspects of Oxy-Acetylene", R. C. Rohrabacker.

The convention finished with a banquet at the Hotel Commodore, Thursday evening, October 6.

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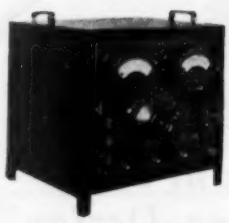

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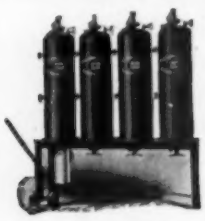
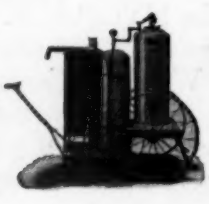
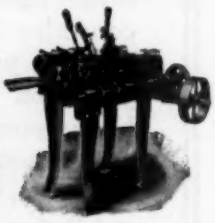

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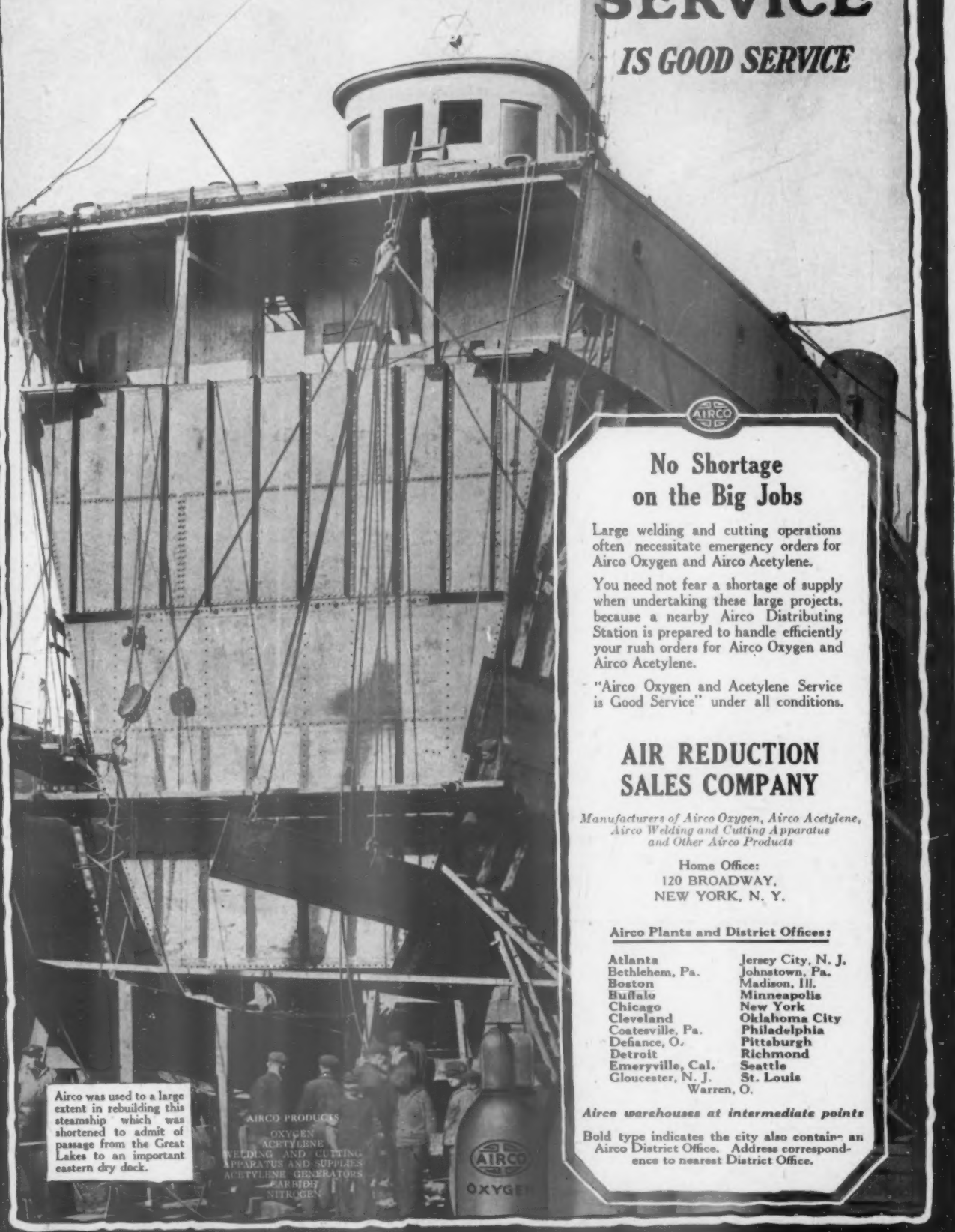

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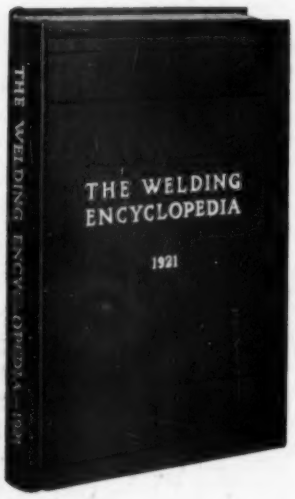

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